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(21) International Application Number: PCT/US95/14700 (22) International Filing Date: 13 November 1995 (13.11.95) (30) Priority Data: 08/339,051 14 November 1994 (14.11.94) US 08/539,410 6 November 1995 (06.11.95) US (71) Applicant: WARNER-LAMBERT COMPANY [US/US]; 201 Tabor Road, Morris Plains, NJ 07950 (US). (72) Inventors: BLANKLEY, Clifton, John; 3724 Vorhies Road, Ann Arbor, MI 48105 (US). DOHERTY, Annette, Mar- ian; 106 Tulip Tree Court, Ann Arbor, MI 48103 (US). HAMBY, James, Marino; 4390 Chad Court, Ann Arbor, MI 48103 (US). PANEK, Robert, Lee; 404 Kings Way, Can- ton, MI 48188 (US). SCHROEDER, Mel, Conrad; 7858 Ridgeway Court, Dexter, MI 48130 (US). SHOWALTER, Howard, Daniel, Hollis; 3578 Lamplighter Drive, Ann Ar- bor, MI 48103 (US). CONNOLLY, Clco; 36367 Hammer Lane, Livonia, MI 48152 (US). (74) Agents: RYAN, M., Andrea; Warner-Lambert Company, 201 Tabor Road, Morris Plains, NJ 07950 (US) et al.		(81) Designated States: AM, AU, BG, BY, CA, CN, CZ, EE, FI, GE, HU, JP, KG, KR, KZ, LT, LV, MD, MX, NO, NZ, PL, RO, RU, SG, SI, SK, TJ, UA, UZ, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE). Published <i>Without international search report and to be republished upon receipt of that report.</i>
(54) Title: 6-ARYL PYRIDO[2,3-d]PYRIMIDINES AND NAPHTHYRIDINES FOR INHIBITING PROTEIN TYROSINE KINASE MEDIATED CELLULAR PROLIFERATION (57) Abstract 6-Aryl pyrido[2,3-d]pyrimidines and naphthyridines are inhibitors of protein tyrosine kinase, and are thus useful in treating cellular proliferation mediated thereby. The compounds are especially useful in treating atherosclerosis, restenosis, psoriasis, as well as bacterial infections.		

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6-ARYL PYRIDO[2,3-d]PYRIMIDINES AND NAPHTHYRIDINES FOR
INHIBITING PROTEIN TYROSINE KINASE
MEDIATED CELLULAR PROLIFERATION

5

FIELD OF THE INVENTION

This invention relates to inhibition of protein
tyrosine kinase (PTK) mediated cellular proliferation.
10 More specifically, this invention relates to the use of
pyrido[2,3-d]pyrimidines and naphthyridine compounds in
inhibiting cellular proliferation and protein tyrosine
kinase enzymatic activity.

15

BACKGROUND OF THE INVENTION

Many disease states are characterized by the
uncontrolled proliferation and differentiation of
20 cells. These disease states encompass a variety of
cell types and maladies such as, cancer, athero-
sclerosis, and restenosis. Growth factor stimulation,
autophosphorylation, and the phosphorylation of
intracellular protein substrates are important
25 biological events in the pathomechanisms of
proliferative diseases.

In normal cells, the phosphorylation of tyrosine
residues on protein substrates serves a critical
function in intracellular growth signaling pathways
30 initiated by stimulated extracellular growth factor
receptors. For example, the association of growth
factors such as Platelet Derived Growth Factor (PDGF),
Fibroblast Growth Factor (FGF), and Epidermal Growth
Factor (EGF) with their respective extracellular
35 receptors activates intracellular tyrosine kinase
enzyme domains of these receptors, thereby catalyzing

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the phosphorylation of either intracellular substrates or the receptors themselves. The phosphorylation of growth factor receptors in response to ligand binding is known as autophosphorylation.

5 For example, the EGF receptor has as its two most important ligands EGF and Transforming Growth Factor α , (TGF α). The receptors appear to have only minor functions in normal adult humans, but are implicated in the disease processes of a large portion of all
10 cancers, especially colon and breast cancer. The closely related Erb-B2 and Erb-B3 receptors have a family of Heregulins as their major ligands, and receptor overexpression and mutation have been unequivocally demonstrated as the major risk factor in
15 poor prognosis breast cancer.

The proliferation and directed migration of vascular smooth muscle cells (VSMC) are important components in such processes as vascular remodeling, restenosis and atherosclerosis. Platelet-derived growth factor has been identified as one of the most potent endogenous VSMC mitogens and chemoattractants. Elevated vascular mRNA expression of PDGF-A and -B chains and PDGF receptors has been observed in balloon-injured rat carotid arteries (J. Cell. Biol.,
20 111:2149-2158 (1990)). In this injury model, infusion of PDGF also greatly increases intimal thickening and migration of VSMC (J. Clin. Invest., 89:507-511
25 (1992)). Furthermore, PDGF-neutralizing antibodies significantly reduce intimal thickening following balloon injury (Science, 253:1129-1132 (1991)).
30

Both acidic fibroblast growth factor (aFGF) and basic fibroblast growth factor (bFGF) have many biological activities, including the ability to promote cellular proliferation and differentiation. Tyrphostin
35 receptor tyrosine kinase inhibitors which block the PDGF signal transduction pathway have been shown to

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inhibit PDGF stimulated receptor tyrosine kinase phosphorylation in vivo in the rat model of balloon angioplasty (Drug Develop. Res., 29:158-166 (1993)). Direct evidence in support of FGF involvement in VSMC has been reported by Lindner and Reidy (Proc. Natl. Acad. Sci. USA, 88:3739-3743 (1991)), who demonstrated that the systemic injection of a neutralizing antibody against bFGF prior to balloon angioplasty of rat carotid arteries inhibited injury-induced medial SMC proliferation by greater than 80% when measured 2 days after injury. It is likely that bFGF released from damaged cells is acting in a paracrine manner to induce VSMC growth. Recently, Lindner and Reidy (Cir. Res., 73:589-595 (1993)) demonstrated an increased expression of both mRNA for bFGF and FGFR-1 in replicating VSMCs and endothelium in en face preparations of balloon-injured rat carotid arteries. The data provides evidence that in injured arteries the ligand/receptor system of bFGF and FGFR-1 may be involved in the continued proliferative response of VSMCs leading to neointima formation.

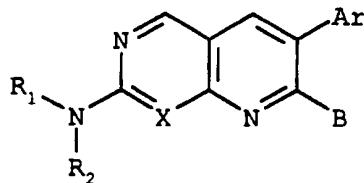
Thus, EGF, PDGF, FGF, and other growth factors play pivotal roles in the pathomechanisms of cellular proliferative diseases such as cancer, atherosclerosis, and restenosis. Upon association with their respective receptors, these growth factors stimulate tyrosine kinase activity as one of the initial biochemical events leading to DNA synthesis and cell division. It thereby follows that compounds which inhibit protein tyrosine kinases associated with intracellular growth factor signal transduction pathways are useful agents for the treatment of cellular proliferative diseases. We have now discovered that certain pyrido[2,3-d]-pyrimidines and naphthyridines inhibit protein tyrosine kinases, and are useful in treating and preventing atherosclerosis, restenosis, and cancer.

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Several pyrido[2,3-d]pyrimidines and naphthyridines are known. For example, U.S. Patent Number 3,534,039 discloses a series of 2,7-diamino-6-arylpyrido[2,3-d]pyrimidine compounds as diuretic agents; U.S. Patent Number 3,639,401 discloses a series of 6-aryl-2,7-bis[(trialkylsilyl)amino]pyrido[2,3-d]pyrimidine compounds as diuretic agents; U.S. Patent Number 4,271,164 discloses a series of 6-substituted-arylpyrido[2,3-d]pyrimidin-7-amines and derivatives as antihypertensive agents; European Published Application Number 0 537 463 A2 discloses a series of substituted-pyrido[2,3-d]pyrimidines useful as herbicides; U.S. Patent Number 4,771,054 discloses certain naphthyridines as antibiotics. None of the foregoing references teach the compounds of this invention or suggest such compounds are useful for treating atherosclerosis, restenosis, and cancer.

SUMMARY OF THE INVENTION

This invention provides new compounds characterized as pyrido[2,3-d]pyrimidines and 1,6-naphthyridines which are useful in inhibiting protein tyrosine kinase, and thus are effective in treating cellular proliferative diseases of atherosclerosis, restenosis, and cancer. The invention is more particularly directed to compounds defined by the Formula I



I

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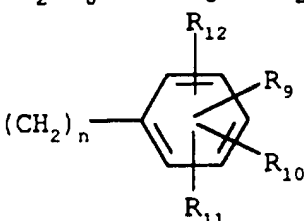
wherein

X is CH or N;

B is halo, hydroxy, or NR_3R_4 ;

R_1 , R_2 , R_3 , and R_4 independently are hydrogen,
 5 $\text{C}_1\text{-C}_8$ alkyl, $\text{C}_2\text{-C}_8$ alkenyl, $\text{C}_2\text{-C}_8$ alkynyl, Ar' , amino,
 $\text{C}_1\text{-C}_8$ alkylamino or di- $\text{C}_1\text{-C}_8$ alkylamino; and wherein
 the alkyl, alkenyl, and alkynyl groups may be
 substituted by NR_5R_6 , where R_5 and R_6 are independently
 hydrogen, $\text{C}_1\text{-C}_8$ alkyl, $\text{C}_2\text{-C}_8$ alkenyl, $\text{C}_2\text{-C}_8$ alkynyl,

10

$\text{C}_3\text{-C}_{10}$ cycloalkyl or $(\text{CH}_2)_n$ -, and wherein

15 any of the foregoing alkyl, alkenyl, and alkynyl groups
 may be substituted with hydroxy or a 5- or 6-membered
 carbocyclic or heterocyclic ring containing 1 or
 2 heteroatoms selected from nitrogen, oxygen, and
 sulfur, and R_9 , R_{10} , R_{11} , and R_{12} independently are
 20 hydrogen, nitro, trifluoromethyl, phenyl, substituted

phenyl, $-\text{C}\equiv\text{N}$, $-\text{COOR}_8$, $-\text{COR}_8$, $-\overset{\text{S}}{\underset{|}{\text{C}}}\text{R}_8$, $-\overset{\text{NH}}{\underset{||}{\text{C}}}\text{R}_8$, SO_2R_8 , halo,
 $\text{C}_1\text{-C}_8$ alkyl, $\text{C}_1\text{-C}_8$ alkoxy, thio, $-\text{S}-\text{C}_1\text{-C}_8$ alkyl,
 25 hydroxy, $\text{C}_1\text{-C}_8$ alkanoyl, $\text{C}_1\text{-C}_8$ alkanoyloxy, or $-\text{NR}_5\text{R}_6$,
 or R_9 and R_{10} taken together when adjacent can be
 methylenedioxy; n is 0, 1, 2, or 3; and wherein R_5 and
 R_6 together with the nitrogen to which they are
 attached can complete a ring having 3 to 6 carbon atoms
 30 and optionally containing a heteroatom selected from
 nitrogen, oxygen, and sulfur;

R_1 and R_2 together with the nitrogen to which they
 are attached, and R_3 and R_4 together with the nitrogen
 to which they are attached, can also be

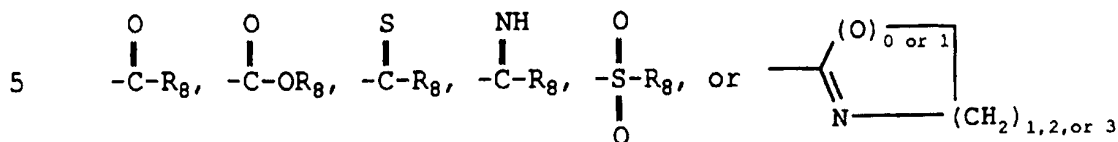
35

$(\text{H}, \text{CH}_3, \text{or } \text{NH}_2)$

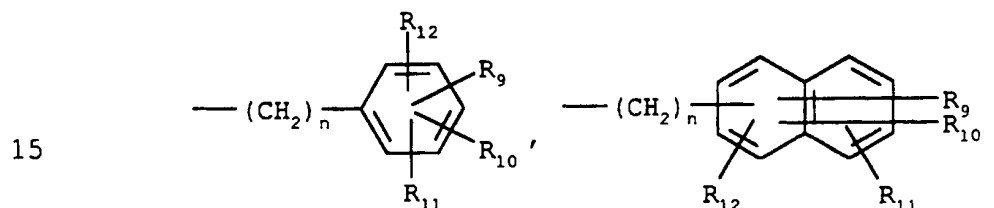
$-\text{N}=\text{C}-\text{R}_8$, or can complete a ring having 3 to 6 carbon
 atoms and optionally containing 1 or 2 heteroatoms

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selected from nitrogen, oxygen, and sulfur, and R_1 and R_3 additionally can be an acyl analog selected from



10 in which R_8 is hydrogen, $\text{C}_1\text{-C}_8$ alkyl, $\text{C}_2\text{-C}_8$ alkenyl, $\text{C}_2\text{-C}_8$ alkynyl, $\text{C}_3\text{-C}_{10}$ cycloalkyl, optionally containing an oxygen, nitrogen, or sulfur atom,

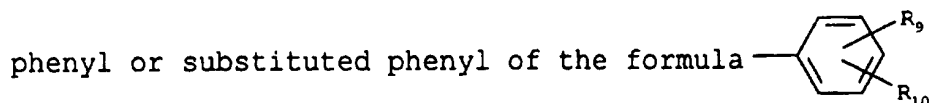


and $\text{-NR}_5\text{R}_6$, and wherein the R_8 alkyl, alkenyl, and alkynyl groups can be substituted by NR_5R_6 ;

20 Ar and Ar' are unsubstituted or substituted aromatic or heteroaromatic groups selected from phenyl, imidazolyl, pyrrolyl, pyridyl, pyrimidyl, benzimidazolyl, benzothienyl, benzofuranyl, indolyl, pyrazinyl, thiazolyl, oxazolyl, isoxazolyl, furanyl, thienyl, naphthyl, wherein the substituents are R_9 , R_{10} , R_{11} , and R_{12} as defined above;

25 and the pharmaceutically acceptable acid and base addition salts thereof; provided that when X is N and B is NR_3R_4 , one of R_3 and R_4 is other than hydrogen.

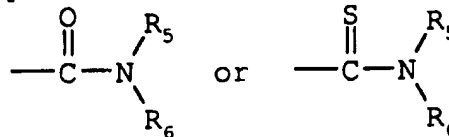
30 Preferred compounds have Formula I wherein Ar is



35 Additionally preferred are compounds wherein B is $\text{-NR}_3\text{R}_4$.

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Further preferred compounds are those wherein one or both of R_1 and R_3 are

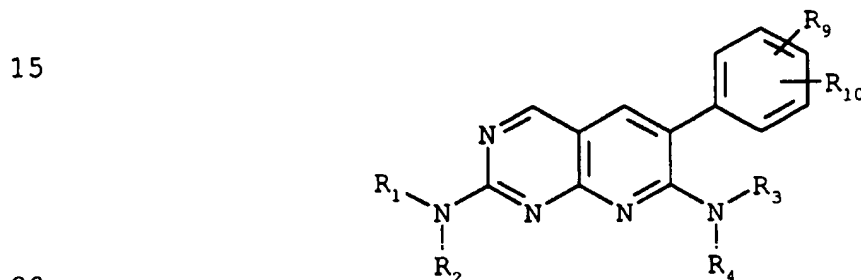


5 and R_2 and R_4 are hydrogen.

Still further preferred compounds have Formula I wherein B is NR_3R_4 , R_1 and R_3 independently are

10 hydrogen, $\begin{array}{c} \text{S} \\ | \\ -\text{CR}_8 \end{array}$ or $\begin{array}{c} \text{O} \\ | \\ -\text{C}-\text{R}_8 \end{array}$ where R_8 is $\text{C}_1\text{-C}_8$ alkyl or NR_5R_6 .

A particularly preferred group of compounds have the formula

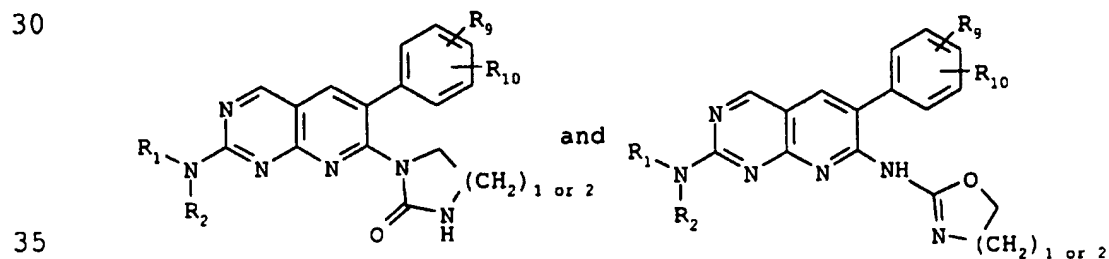


wherein R_2 and R_4 are hydrogen, R_1 and R_3 independently

are hydrogen, $\text{C}_1\text{-C}_8$ alkyl, $\begin{array}{c} \text{S} \\ | \\ -\text{C}-\text{R}_8 \end{array}$ or $\begin{array}{c} \text{O} \\ | \\ -\text{C}-\text{R}_8 \end{array}$, where R_8 is $\text{C}_1\text{-C}_8$ alkyl or NR_5R_6 , R_5 is hydrogen and R_6 is $\text{C}_1\text{-C}_8$ alkyl, and R_9 and R_{10} independently are hydrogen, halo, $\text{C}_1\text{-C}_8$ alkyl, or $\text{C}_1\text{-C}_8$ alkoxy.

25

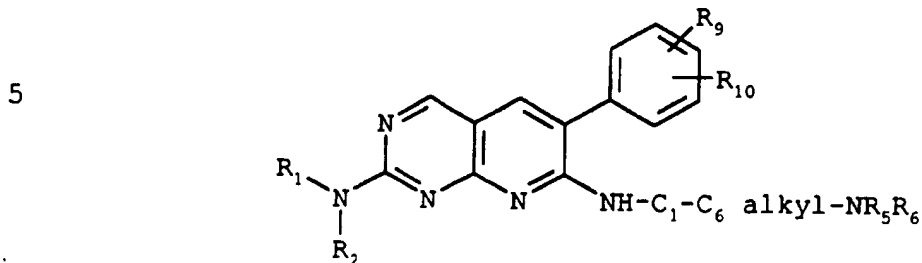
Another preferred group of compounds have the formulas



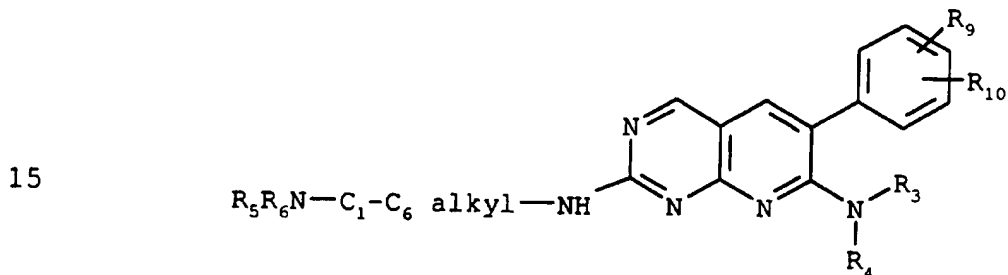
wherein R_1 , R_2 , R_9 , and R_{10} are as defined above.

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Also preferred are compounds of the formula

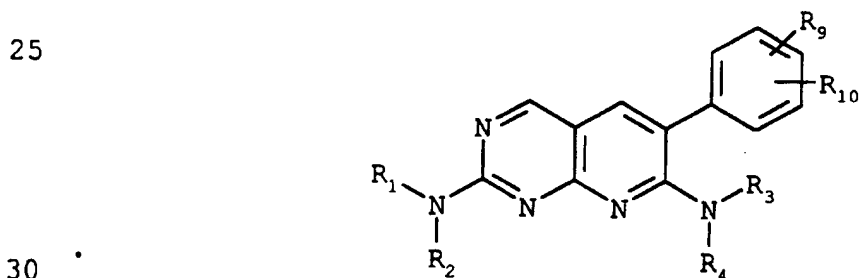


10 Also preferred are compounds of the formula



20 especially where R_5 and R_6 together with the nitrogen to which they are attached from a cyclic ring such as morpholino, piperazino, 4-alkylpiperazino, and the like.

Additionally preferred are compounds of the formula

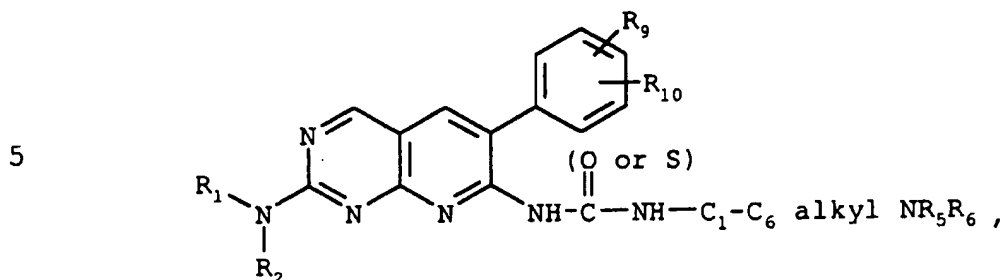


wherein R_2 and R_4 are hydrogen, R_1 and R_3 independently

35 are hydrogen, C_1-C_6 alkyl, $-C(=S)-R_8$ or $-C(=O)-R_8$, where R_8 , R_9 , and R_{10} are as defined above.

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Also preferred are compounds of the formula



10 especially where R₅ and R₆ together with the nitrogen to which they are attached form a cyclic ring such as morpholino, piperazino, 4-alkylpiperazino, and the like.

The most preferred compounds of the invention include the following:

- 15 1-tert-butyl-3-[7-(3-tert-butylureido)-6-(2,6-dichlorophenyl)-pyrido[2,3-d]pyrimidin-2-yl]urea;
 1-[2-amino-6-(2,6-dichlorophenyl)-pyrido[2,3-d]pyrimidin-7-yl]-3-tert-butylurea;
 1-tert-butyl-3-[7-(3-tert-butylureido)-6-o-tolyl-pyrido[2,3-d]pyrimidin-2-yl]urea;
 20 1-[2-amino-6-o-tolyl-pyrido[2,3-d]pyrimidin-7-yl]-3-tert-butylurea;
 1-[2-amino-6-(2,6-dimethylphenyl)-pyrido[2,3-d]pyrimidin-7-yl]-3-tert-butylurea;
 25 N-[2-acetyl-amino-6-(2,6-dichlorophenyl)-pyrido[2,3-d]pyrimidin-7-yl]-acetamide;
 N⁷-butyl-6-phenyl-pyrido[2,3-d]pyrimidine-2,7-diamine;
 3-o-tolyl-[1,6]naphthyridine-2,7-diamine;
 30 3-(2-chlorophenyl)-[1,6]naphthyridine-2,7-diamine;
 N²,N⁷-dimethyl-6-phenyl-pyrido[2,3-d]pyrimidine-2,7-diamine;
 7-amino-6-(2,6-dichlorophenyl)-2-(3-diethylamino-propylamino)-pyrido[2,3-d]pyrimidine;

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- 1-tert-butyl-3-[6-(2,6-dichlorophenyl)-
2-(3-diethylamino-propylamino)-pyrido[2,3-d]pyrimidin-
7-yl]urea;
- 5 1-[2-amino-6-(2,6-dichlorophenyl)-pyrido[2,3-d]
pyrimidin-7-yl]-3-ethylurea;
- 1-[2-amino-6-(2,6-dichlorophenyl)-pyrido[2,3-d]-
pyrimidin-7-yl]-3-(3-morpholino-4-yl-propyl)-thiourea;
- 1-(2-amino-6-(2,6-dichlorophenyl)-pyrido[2,3-d]
pyrimidin-7-yl)-imidazolidin-2-one;
- 10 N'-[7-(3-tert-Butyl-ureido)-6-(2,6-dichloro-
phenyl)-pyrido[2,3-d]pyrimidin-2-yl]-N,N-dimethyl-
formamidine;
- N'-[6-(2,6-Dichloro-phenyl)-7-(dimethylamino-
methyleamino)-pyrido[2,3-d]pyrimidin-2-yl]-N,N-
15 dimethyl-formamidine;
- 1-tert-Butyl-3-[2-(3-diethylamino-propylamino)-6-
(2,6-dimethyl-phenyl)-pyrido[2,3-d]pyrimidin-7-yl]-
urea;
- 20 1-tert-Butyl-3-[6-(2,6-dichloro-phenyl)-2-(4-
diethylamino-butylamino)-pyrido[2,3-d]pyrimidin-7-yl]-
urea;
- 1-[2-Amino-6-(2,3-dichloro-phenyl)-pyrido[2,3-
d]pyrimidin-7-yl]-3-tert-butyl-urea;
- 25 1-[2-Amino-6-(3-methoxy-phenyl)-pyrido[2,3-
d]pyrimidin-7-yl]-3-tert-butyl-urea;
- 1-[2-Amino-6-(2,3-dimethyl-phenyl)-pyrido[2,3-
d]pyrimidin-7-yl]-3-tert-butyl-urea;
- 1-tert-Butyl-3-[6-(2,6-dichloro-phenyl)-2-[3-(4-
methyl-piperazin-1-yl)-propylamino]-pyrido[2,3-
30 d]pyrimidin-7-yl]-urea;
- N'-[6-(2,6-Dichloro-phenyl)-2-(3-diethylamino-
propylamino)-pyrido[2,3-d]pyrimidin-7-yl]-N,N-dimethyl-
formamidine;
- 35 1-[2-Amino-6-(2,3,6-trichloro-phenyl)-pyrido[2,3-
d]pyrimidin-7-yl]-3-tert-butyl-urea;

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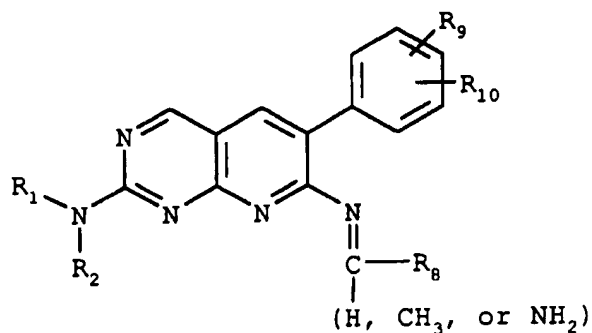
- 1-[2-Amino-6-(2-methoxy-phenyl)-pyrido[2,3-d]pyrimidin-7-yl]-3-tert-butyl-urea;
- 1-tert-Butyl-3-[6-(2,6-dichloro-phenyl)-2-[(3-dimethylamino-propyl)-methyl-amino]-pyrido[2,3-d]pyrimidin-7-yl]-urea;
- 5 1-(2-Amino-6-pyridin-3-yl-pyrido[2,3-d]pyrimidin-7-yl)-3-tert-butyl-urea;
- 1-[6-(2,6-Dichloro-phenyl)-2-[3-(4-methyl-piperazin-1-yl)-propylamino]-pyrido[2,3-d]pyrimidin-7-yl]-3-phenyl-urea;
- 10 1-[2-Amino-6-(2,3,5,6-tetramethyl-phenyl)-pyrido[2,3-d]pyrimidin-7-yl]-3-tert-butyl-urea;
- 1-[2-Amino-6-(2-bromo-6-chloro-phenyl)-pyrido[2,3-d]pyrimidin-7-yl]-3-tert-butyl-urea;
- 15 1-(2-Amino-6-pyridin-4-yl-pyrido[2,3-d]pyrimidin-7-yl)-3-tert-butyl-urea;
- 1-[2-Amino-6-(3,5-dimethyl-phenyl)-pyrido[2,3-d]pyrimidin-7-yl]-3-tert-butyl-urea;
- 1-[2-Amino-6-(2-bromo-6-chloro-phenyl)-pyrido[2,3-d]pyrimidin-7-yl]-3-tert-butyl-urea;
- 20 1-[6-(2,6-Dichloro-phenyl)-2-(4-diethylamino-butylamino)-pyrido[2,3-d]pyrimidin-7-yl]-3-ethyl-urea;
- Propane-1-sulfonic acid [2-amino-6-(2,6-dichloro-phenyl)-pyrido[2,3-d]pyrimidin-7-yl]-amide;
- 25 1-[2-Amino-6-(2,6-difluoro-phenyl)-pyrido[2,3-d]pyrimidin-7-yl]-3-tert-butyl-urea;
- 1-tert-Butyl-3-[6-(2,6-dibromo-phenyl)-2-(3-diethylamino-propylamino)-pyrido[2,3-d]pyrimidin-7-yl]-urea;
- 30 1-tert-Butyl-3-[6-(2,6-dichloro-phenyl)-2-(3-dimethylamino-2,2-dimethyl-propylamino)-pyrido[2,3-d]pyrimidin-7-yl]-urea;
- 1-tert-Butyl-3-[6-(2,6-dichloro-phenyl)-2-[3-(2-methyl-piperidin-1-yl)-propylamino]-pyrido[2,3-d]pyrimidin-7-yl]-urea;
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- 1-[2-Amino-6-(2,4,6-trimethyl-phenyl)-
pyrido[2,3-d]pyrimidin-7-yl]-3-tert-butyl-urea;
1-Adamantan-1-yl-3-(6-(2,6-dichloro-phenyl)-2-
[3-(4-methyl-piperazin-1-yl)-propylamino]-
5 pyrido[2,3-d]pyrimidin-7-yl)-urea;
1-Cyclohexyl-3-(6-(2,6-dichloro-phenyl)-2-
[3-(4-methyl-piperazin-1-yl)-propylamino]-
pyrido[2,3-d]pyrimidin-7-yl)-urea;
1-{6-(2,6-Dichloro-phenyl)-2-[3-(4-methyl-
10 piperazin-1-yl)-propylamino]}-pyrido[2,3-d]pyrimidin-
7-yl)-3-(3-methoxy-phenyl)-urea;
1-tert-Butyl-3-(6-(2,6-dichloro-phenyl)-2-
[4-(4-methyl-piperazin-1-yl)-butylamino]-
pyrido[2,3-d]pyrimidin-7-yl)-urea;
15 1-tert-Butyl-3-(6-(2,6-dichloro-phenyl)-2-
[3-(4-methyl-piperazin-1-yl)-propylamino]-
pyrido[2,3-d]pyrimidin-7-yl)-thiourea;
1-tert-Butyl-3-[2-[3-(4-methyl-piperazin-1-yl)-
propylamino]-6-(2,3,5,6-tetramethyl-phenyl)-
20 pyrido[2,3-d]pyrimidin-7-yl)-urea;
1-Allyl-3-(6-(2,6-dichloro-phenyl)-2-[3-(4-methyl-
piperazin-1-yl)-propylamino]}-pyrido[2,3-d]pyrimidin-7-
yl)-urea;
6-(2,6-Dichloro-phenyl)-N⁷-(5,6-dihydro-4H-
25 [1,3]oxazin-2-yl)-N²-[3-(4-methyl-piperazin-1-yl)-
propyl]-pyrido[2,3-d]pyrimidine-2,7-diamine; and
3-[6-(2,6-Dichloro-phenyl)-2-[3-(4-methyl-
piperazin-1-yl)-propylamino]}-pyrido[2,3-d]pyrimidin-
7-yl)-1,1-diethyl-urea.
30 Yet another preferred group of compounds are
amidines of the formula

-13-

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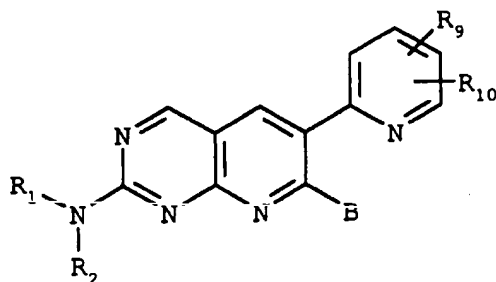


especially where R₈ is -NR₅R₆.

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Another preferred group of compounds have Formula I wherein Ar is other than phenyl or substituted phenyl. Typical of such compounds are pyridines of the formula

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This invention also provides pharmaceutical formulations comprising a compound of Formula I together with a pharmaceutically acceptable carrier, diluent, or excipient therefor.

25

Compounds within the scope of the present invention have a specific affinity towards one or more of the substrate site of the tyrosine kinase domains of EGF, FGF, PDGF, V-src and C-src. Compounds within the scope of the present invention have effectively inhibited EGF and PDGF autophosphorylation of the receptor and inhibited vascular smooth muscle cell proliferation and migration.

30

As inhibitors of protein kinase, the compounds of the instant invention are useful in controlling proliferative disorders including leukemia, cancer,

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psoriasis, vascular smooth muscle proliferation associated with atherosclerosis, and postsurgical vascular stenosis and restenosis in mammals.

5 A further embodiment of this invention is a method of treating subjects suffering from diseases caused by vascular smooth muscle proliferation. The method entails inhibiting vascular smooth muscle proliferation and/or migration by administering an effective amount of a compound of Formula I to a subject in need of
10 treatment.

Finally, the present invention is directed to methods for the preparation of a compound of Formula I and synthetic intermediates.

15

DETAILED DESCRIPTION OF THE INVENTION

The compounds of the present invention can exist in unsolvated forms as well as solvated forms, including hydrated forms. In general, the solvated
20 forms, including hydrated forms, are equivalent to unsolvated forms and are intended to be encompassed within the scope of the present invention.

In the compounds of Formula I, the term " C_1-C_8 alkyl" means a straight or branched hydrocarbon radical having from 1 to 8 carbon atoms and includes, for
25 example, methyl, ethyl, n-propyl, isopropyl, n-butyl, sec-butyl, isobutyl, tert-butyl, n-pentyl, 2,2-dimethylpropyl, n-hexyl, n-heptyl, n-octyl, and the like. Preferred are C_1-C_6 alkyl groups.

"Halo" includes fluoro, chloro, bromo, and iodo.

" C_2-C_8 Alkenyl" means straight and branched hydrocarbon radicals having from 2 to 8 carbon atoms and 1 double bond and includes ethenyl, 3-buten-1-yl,
35 2-ethenylbutyl, 3-octen-1-yl, and the like. Typical C_2-C_8 alkynyl groups include propynyl, 2-butyne-1-yl,

-15-

3-pentyn-1-yl, and the like. C₂-C₆ Alkenyl are preferred.

"C₃-C₁₀ Cycloalkyl" means a cyclic or bicyclic hydrocarbonyl group such as cyclopropyl, cyclobutyl, cyclohexyl, cyclopentyl, adamantyl, bicyclo[3.2.1]octyl, bicyclo[2.2.1]heptyl, and the like, as well heterocyclics such as piperazinyl, tetrahydropyranyl, pyrrolidinyl, and the like.

"C₁-C₈ Alkoxy" refers to the alkyl groups mentioned above binding through oxygen, examples of which include methoxy, ethoxy, isopropoxy, tert-butoxy, n-octyloxy, and the like. C₁-C₆ Alkoxy groups are preferred.

Typical "C₁-C₈ alkanoyl" groups include formyl, acetyl, propionyl, butyryl, and isobutyryl. "C₁-C₈ alkanoyloxy" includes acetoxo, tert-butanoyloxy, pentanoyloxy, and the like.

The alkyl, alkenyl, and alkynyl groups may be substituted with NR₅R₆ and 5- or 6-membered carbocyclic and heterocyclic groups, containing 1 or 2 heteroatoms selected from nitrogen, oxygen, and sulfur. Such rings may be substituted, for example with one or two C₁-C₆ alkyl groups. Examples include dimethylaminomethyl, 4-diethylamino-3-buten-1-yl, 5-ethylmethylamino-3-pentyn-1-yl-4-morpholinobutyl, 4-(4-methylpiperazin-1-yl)butyl, 4-tetrahydropyridinylbutyl-, 2-methyltetrahydropyridinomethyl-, 3-imidazolidin-1-ylpropyl, 4-tetrahydrothiazol-3-yl-butyl, phenylmethyl, 3-chlorophenylmethyl, and the like.

The terms "Ar" and "Ar'" refer to unsubstituted and substituted aromatic and heteroaromatic groups such as phenyl, 3-chlorophenyl, 2,6-dibromophenyl, pyridyl, 3-methylpyridyl, benzothienyl, 2,4,6-tribromophenyl, 4-ethylbenzothienyl, furanyl, 3,4-diethylfuranyl, naphthyl, 4,7-dichloronaphthyl, and the like.

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Preferred Ar and Ar' groups are phenyl and phenyl substituted by 1, 2, or 3 groups independently selected from halo, alkyl, alkoxy, thio, thioalkyl, hydroxy, alkanoyl, -CN, -NO₂, -COOR₈, -CF₃ alkanoyloxy, or amino of the formula -NR₅R₆. Disubstituted phenyl is preferred, and 2,6-disubstituted phenyl is especially preferred. Other preferred Ar and Ar' groups include pyridyl, e.g., 2-pyridyl and 4-pyridyl.

Typical Ar and Ar' substituted phenyl groups thus include 2-aminophenyl, 3-chloro-4-methoxyphenyl, 2,6-diethylphenyl, 2-n-hexyl-3-fluorophenyl, 3-hydroxyphenyl, 3,4-dimethoxyphenyl, 2,6-dichlorophenyl, 2-chloro-6-methylphenyl, 2,4,6-trichlorophenyl, 2,6-dimethoxyphenyl, 2,6-dihydroxyphenyl, 2,6-dibromophenyl, 2,6-dinitrophenyl, 2,6-di-(trifluoromethyl)phenyl, 2,6-dimethylphenyl, 2,3,6-trimethylphenyl, 2,6-dibromo-4-methylphenyl, and the like.

The compounds of Formula I are capable of further forming both pharmaceutically acceptable acid addition and/or base salts. All of these forms are within the scope of the present invention.

Pharmaceutically acceptable acid addition salts of the compounds of Formula I include salts derived from inorganic acids such as hydrochloric, nitric, phosphoric, sulfuric, hydrobromic, hydriodic, phosphorous, and the like, as well as the salts derived from organic acids, such as aliphatic mono- and dicarboxylic acids, phenyl-substituted alkanolic acids, hydroxy alkanolic acids, alkanedioic acids, aromatic acids, aliphatic and aromatic sulfonic acids, etc. Such salts thus include sulfate, pyrosulfate, bisulfate, sulfite, bisulfite, nitrate, phosphate, monohydrogenphosphate, dihydrogenphosphate, metaphosphate, pyrophosphate, chloride, bromide, iodide, acetate, propionate, caprylate, isobutyrate,

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oxalate, malonate, succinate, suberate, sebacate, fumarate, maleate, mandelate, benzoate, chlorobenzoate, methylbenzoate, dinitrobenzoate, phthalate, benzenesulfonate, toluenesulfonate, phenylacetate, citrate, lactate, maleate, tartrate, methanesulfonate, and the like. Also contemplated are salts of amino acids such as arginate and the like and gluconate, galacturonate (see, for example, Berge S.M., et al., "Pharmaceutical Salts," J. of Pharmaceutical Science, 66:1-19 (1977)).

The acid addition salts of said basic compounds are prepared by contacting the free base form with a sufficient amount of the desired acid to produce the salt in the conventional manner. The free base form may be regenerated by contacting the salt form with a base and isolating the free base in the conventional manner. The free base forms differ from their respective salt forms somewhat in certain physical properties such as solubility in polar solvents, but otherwise the salts are equivalent to their respective free base for purposes of the present invention.

Pharmaceutically acceptable base addition salts are formed with metals or amines, such as alkali and alkaline earth metals or organic amines. Examples of metals used as cations are sodium, potassium, magnesium, calcium, and the like. Examples of suitable amines are N,N'-dibenzylethylenediamine, chloro-procaine, choline, diethanolamine, ethylenediamine, N-methylglucamine, and procaine (see, for example, Berge S.M., et al., "Pharmaceutical Salts," J. of Pharmaceutical Science, 66:1-19 (1977)).

The base addition salts of said acidic compounds are prepared by contacting the free acid form with a sufficient amount of the desired base to produce the salt in the conventional manner. The free acid form may be regenerated by contacting the salt form with an

-18-

acid and isolating the free acid in the conventional manner. The free acid forms differ from their respective salt forms somewhat in certain physical properties such as solubility in polar solvents, but otherwise the salts are equivalent to their respective free acid for purposes of the present invention.

While the forms of the invention herein constitute presently preferred embodiments, many others are possible. It is not intended herein to mention all of the possible equivalent forms or ramifications of the invention. It is understood that the terms used herein are merely descriptive rather than limiting, and that various changes may be made without departing from the spirit or scope of the invention.

Compounds of Formula I may be prepared according to the syntheses outlined in Schemes I-VII. Although these schemes often indicate exact structures, the methods apply widely to analogous compounds of Formula I, given appropriate consideration to protection and deprotection of reactive functional groups by methods standard to the art of organic chemistry. For example, hydroxy groups, in order to prevent unwanted side reactions, generally need to be converted to ethers or esters during chemical reactions at other sites in the molecule. The hydroxy protecting group is readily removed to provide the free hydroxy group. Amino groups and carboxylic acid groups are similarly derivatized to protect them against unwanted side reactions. Typical protecting groups, and methods for attaching and cleaving them, are described fully by Greene and Wuts in Protective Groups in Organic Synthesis, John Wiley and Sons, New York, (2nd Ed, 1991), and McOmie, Protective Groups in Organic Chemistry, Plenum Press, New York, 1973.

Scheme I describes a typical method for the preparation of 1-tert-butyl-3-[7-(3-tert-butylureido)-

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6-(aryl)-pyrido[2,3-d]pyrimidin-2-yl]ureas and 1-[2-Amino-6-(aryl)-pyrido[2,3-d]pyrimidin-7-yl]-3-tert-butylureas from the key intermediate 2,7-diamino-6-(aryl)-pyrido[2,3-d]pyrimidine, which can be prepared
5 by the method of U.S. Patent Number 3,534,039. Generally, the reaction can be accomplished by reacting 2,7-diamino-6-(aryl)-pyrido[2,3-d]pyrimidine compounds with one equivalent of an acylating agent, such as an alkyl isocyanate, isothiocyanate, carbamoyl chloride,
10 carbamoyl bromide, sulfamoyl chloride, chloroformate, or other activated acid derivatives such as symmetrical anhydrides, mixed anhydride, and the like. The reaction is carried out in neat isocyanate, or in the presence of a base, preferably sodium hydride in a
15 suitable unreactive solvent such as dimethylformamide, dioxane, or the like. The starting material, a 2,7-diamino-6-(aryl)-pyrido[2,3-d]pyrimidine, can be reacted in the same manner as described above using a two-fold excess or greater of acylating reagent to give
20 primarily the diacylated compounds, for example a 1-tert-butyl-3-[7-(3-tert-butylureido)-6-(aryl)-pyrido[2,3-d]pyrimidin-2-yl]urea.

The acylation generally is substantially complete when conducted for about 1 to 3 hours at a temperature
25 of about 20° to about 80°C. The product is readily isolated by normal methods, for instance by filtering any solids and removing the reaction solvent by evaporation. The product can be purified if desired by routine methods, for instance crystallization from
30 organic solvents such as ethyl acetate, dichloromethane, hexane, and the like, as well as chromatography over solid supports such as silica gel. The compounds of the invention typically are solids which are readily crystallized.

35 Scheme II illustrates a typical acylation of a 2,7-diamino-6-(aryl)-pyrido[2,3-d]pyrimidine using a

-20-

two-fold or larger excess of acetic anhydride with heating to prepare the diacylated product, for example an N-[2-acetylamino-6-(aryl)-pyrido[2,3-d]pyrimidin-7-yl]-acetamide. More generally, diacylated compounds of this type can be prepared by this method starting from the appropriate 2,7-diamino-6-(aryl)-pyrido[2,3-d]pyrimidine compounds and treating them with excess acylating reagents such as acid anhydrides, mixed acid anhydrides, or activated acyl derivatives such as acid chlorides and sulfonyl chlorides. The reaction is generally carried out at a temperature between about 20°C and 200°C. The addition of organic or inorganic bases such as triethylamine and sodium hydroxide may be desired to scavenge acid byproducts produced during the course of the reaction. The diacylated product is readily isolated and purified by chromatography or crystallization as described above.

Scheme III illustrates the preparation of a 6-(aryl)-N⁷-alkyl-pyrido[2,3-d]pyrimidine-2,7-diamine in several steps starting with a 2,7-diamino-6-(aryl)-pyrido[2,3-d]pyrimidine which can be prepared by the method of U.S. Patent Number 3,534,039. Treatment of the starting material with aqueous mineral acid under reflux conditions provides the hydrolysis product 2-amino-6-(aryl)-pyrido[2,3-d]pyrimidin-7-ol. Reaction of the 2-amino-6-(aryl)-pyrido[2,3-d]pyrimidin-7-ol with thionyl chloride under Vilsmeier-Haack conditions affords the chloro-formamidine product N'-(7-chloro-6-(aryl)-pyrido[2,3-d]pyrimidin-2-yl)-N,N-dimethyl-formamidine. This reactive intermediate can be directly reacted with nucleophilic reagents such as amines to give an N⁷-alkyl-6-(aryl)-pyrido[2,3-d]pyrimidine-2,7-diamine. Alternatively, the formamidine functionality can be removed by alcoholysis to provide the 7-chloro derivative, i.e., a 2-amino-7-chloro-6-(aryl)-pyrido[2,3-d]pyrimidine. Reaction of the

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7-chloro intermediate with nucleophilic reagents such as an alkylamine provides the corresponding 6-(aryl)-N⁷-alkyl-pyrido[2,3-d]pyrimidine-2,7-diamine.

5 Scheme IV describes the preparation of a 3-(aryl)-[1,6]naphthyridine-2,7-diamine and represents a general methodology for the preparation of these compounds. The hydrogenolysis of 6-bromo-2,4-diamino-5-cyanopyridine (JACS, 80:2838-2840 (1958)) affords the intermediate 2,4-diamino-5-cyanopyridine. The
10 subsequent hydrogenation of the cyanopyridine compound, for example, in a mixture of formic acid-water employing Raney nickel catalyst, provides a key versatile intermediate 2,4-diamino-5-pyridine-carboxaldehyde. The aldehyde is then condensed with an
15 aryl acetonitrile as described in Scheme IV to provide a 3-(aryl)-[1,6]naphthyridine-2,7-diamine. The condensation reaction is accomplished in the presence of an alkoxide base, for example, sodium ethoxide or sodium 2-ethoxyethoxide, which can be generated in situ
20 by the addition of sodium metal or sodium hydride to ethanol or 2-ethoxyethanol. Scheme IV describes a general methodology for the preparation of the 3-(aryl)-[1,6]naphthyridine-2,7-diamines of this invention.

25 Scheme V illustrates the direct dialkylation of a 6-aryl-pyrido[2,3-d]pyrimidine-2,7-diamine (U.S. Patent Number 3,534,039) with an alkylamine in a bomb at high temperature to afford an N²,N⁷-dialkyl-6-aryl-pyrido[2,3-d]pyrimidine-2,7-diamine. Generally, this
30 reaction is carried out using neat amine reagents such as isobutylamine and n-hexylamine, at a temperature such as 150-300°C in a bomb apparatus.

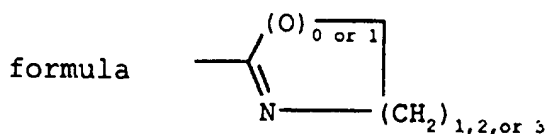
35 Scheme VI illustrates the synthesis of compounds of Formula I wherein R₁ can be an aminoalkyl group such as diethylaminopropyl. A 6-(aryl)-2,7-diamino-pyrido[2,3-d]pyrimidine can be reacted directly with an

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amine nucleophile such as an aminoalkylamine (e.g., $\text{H}_2\text{N alkyl-NR}_5\text{R}_6$), generally in a bomb and in the presence of an acid such as sulfamic acid, to afford an aminoalkyl substituted compound of the invention. The compound can be further acylated, if desired, by routine methods. The compounds are readily isolated and purified by common methodologies such as crystallization and chromatography.

Scheme VII illustrates the synthesis of compounds of Formula I wherein R_3 and R_4 are taken together with the nitrogen to which they are attached to form a cyclic ring. The ring can include another heteroatom such as nitrogen, oxygen, or sulfur. In Scheme VII, a diaminopyridopyrimidine is reacted with a halo ethyl isocyanate to produce an imidazolidinone. The reaction generally is carried out in an organic solvent such as dimethylformamide, and normally in the presence of a base such as sodium hydride. The reaction typically is complete in about 8 to 16 hours when carried out at about 30°C . The product is readily isolated and purified by routine methods.

The above reaction also produces compounds of Formula I wherein R_1 or R_3 is an acyl analog of the



Scheme VIIa illustrates the reaction. The product can be isolated by routine methods such as chromatography, fractional crystallization, and the like.

Another group of compounds provided by the invention are amidines, compounds of Formula I wherein R_1 and R_2 together with the nitrogen to which they are

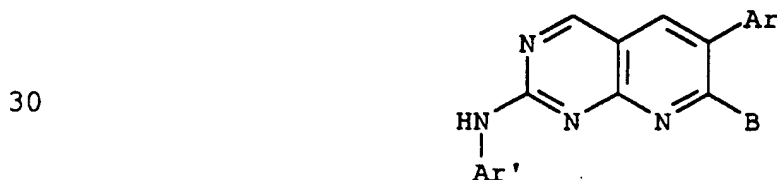
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attached, and R_3 and R_4 together with the nitrogen to which they are attached, can be a group having the

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formula $\begin{array}{c} \text{(H, CH}_3, \text{ or NH}_2\text{)} \\ | \\ \text{-N=C-R}_8 \end{array}$.

Scheme VIII illustrates the synthesis of typical pyridopyrimidine amidines which can be produced by reacting an amino pyridopyrimidine with an acetal of an amide or cyclic amide, for example, the dimethyl acetal of N,N-dimethylformamide, or the dimethylacetal of N-methylpyrrolidone. The reaction typically is carried out by mixing an amino pyridopyrimidine with about an equimolar quantity or excess of an acetal in a mutual solvent such as dimethylformamide, dimethylsulfoxide, tetrahydrofuran, or the like. The reaction generally is complete with about 3 to 6 hours when carried out at a temperature of about 5°C to about 50°C. The product is readily isolated by routine procedures and can be purified, if desired, by normal techniques such as chromatography, crystallization, and the like.

The invention also provides amino pyrido-pyrimidines wherein the amino group is substituted with an aryl Ar' , for example a phenyl, substituted phenyl, pyridyl, thiazolyl, pyrimidyl, and the like. Preferred N-aryl compounds have the formula



where Ar , Ar' , and B are as defined above. Such compounds can be prepared by any of several methods, for example, as described in Schemes IX and X.

In Scheme IX, a pyridopyrimidine substituted with an alkylthio, alkyl sulfoxide or alkyl sulfone, for

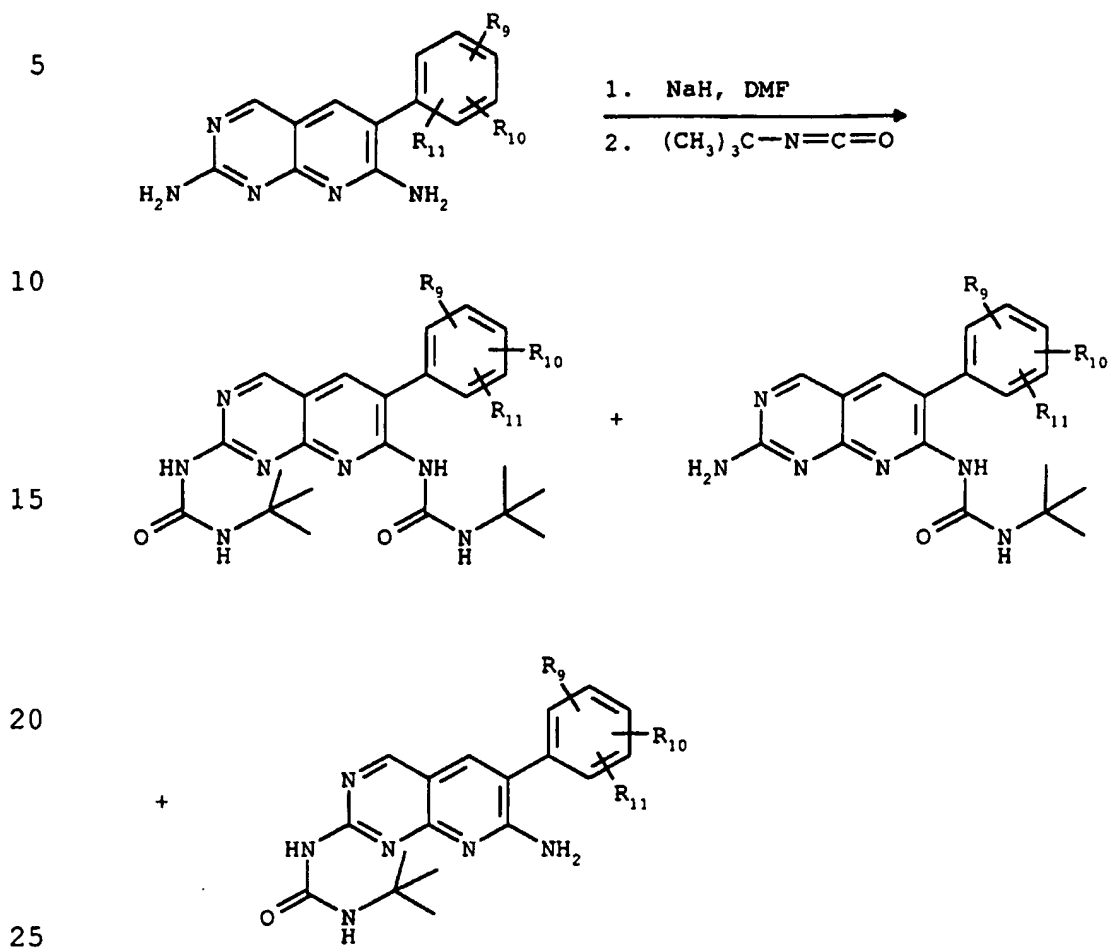
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example at the 2-position, is reacted with an aryl amine (e.g., $\text{Ar}'\text{NH}_2$), to effect displacement of the thio- sulfoxide or sulfone substituent, to produce the corresponding N-aryl amino pyridopyrimidine. The displacement reaction generally is carried out in an organic solvent such as dimethylformamide, normally at a temperature of about 20°C to about 80°C . The reaction generally is complete after about 3 to about 8 hours, and the product is readily isolated by adding the reaction mixture to water and extracting the product into a solvent such as methylene chloride, or the like.

Scheme X illustrates the synthesis of N-aryl amino pyridopyrimidines starting from a suitably substituted pyrimidine, e.g., 4-amino-2-chloropyrimidine-5-carbonitrile. The halo group is displaced by reaction with an aryl amine ($\text{Ar}'\text{NH}_2$) to give the corresponding 2-N-aryl aminopyrimidine, having a cyano group at the 5-position. The cyano group is converted to an aldehyde by reduction with Raney nickel in water and formic acid, and the resulting 2-arylamino-4-amino-pyrimidine-5-carboxaldehyde is reacted with an aryl acetonitrile (e.g., phenylacetonitrile, 2-pyridyl-acetonitrile, or the like) in the manner described in Scheme IV to provide the corresponding N-aryl-amino-pyridopyrimidine of the invention.

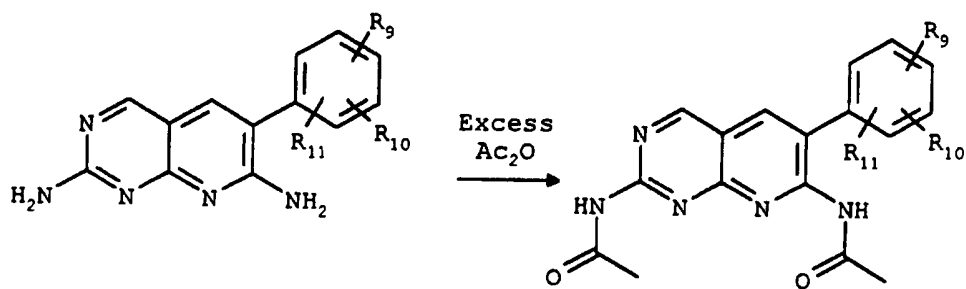
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SCHEME I

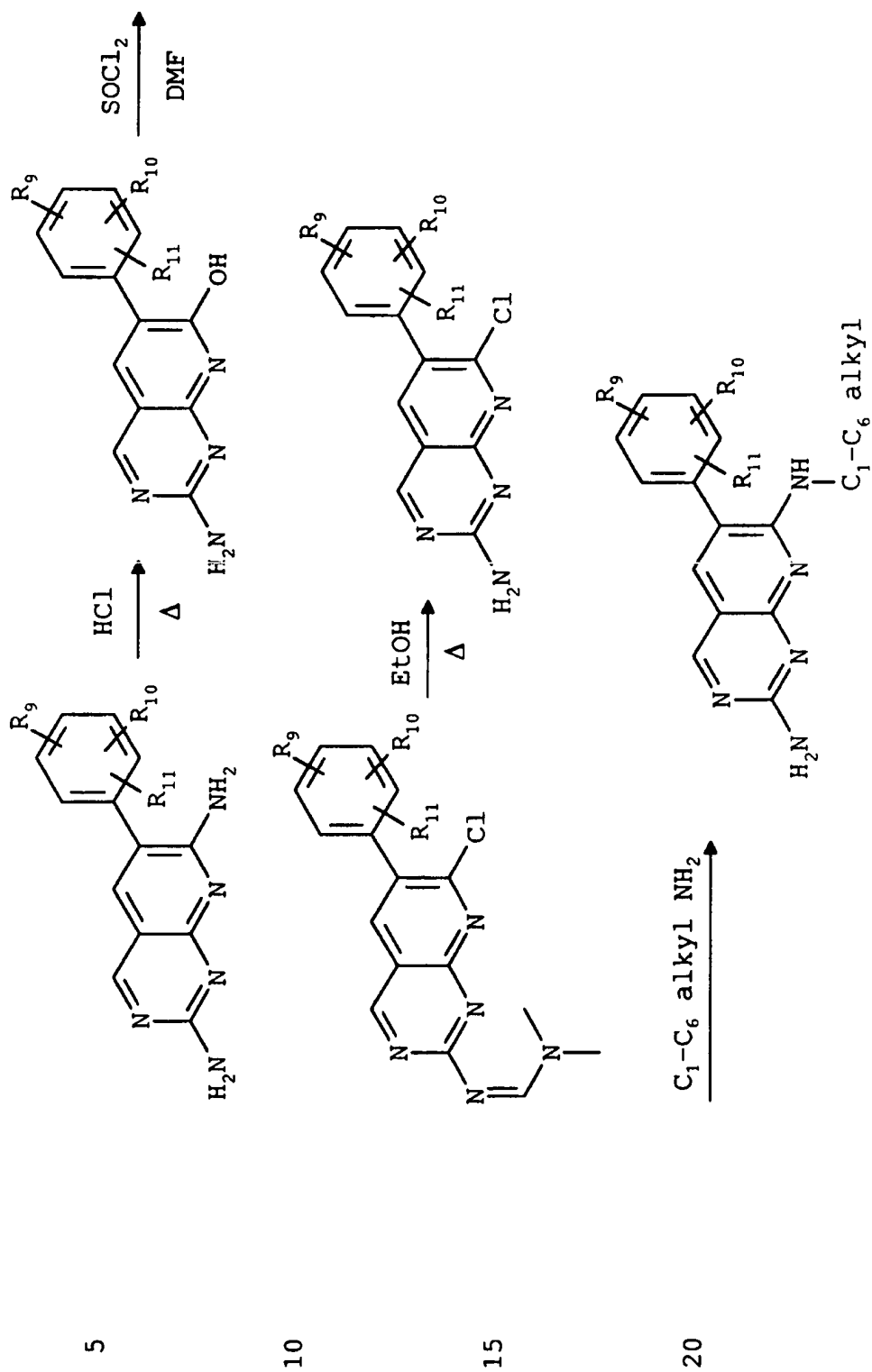


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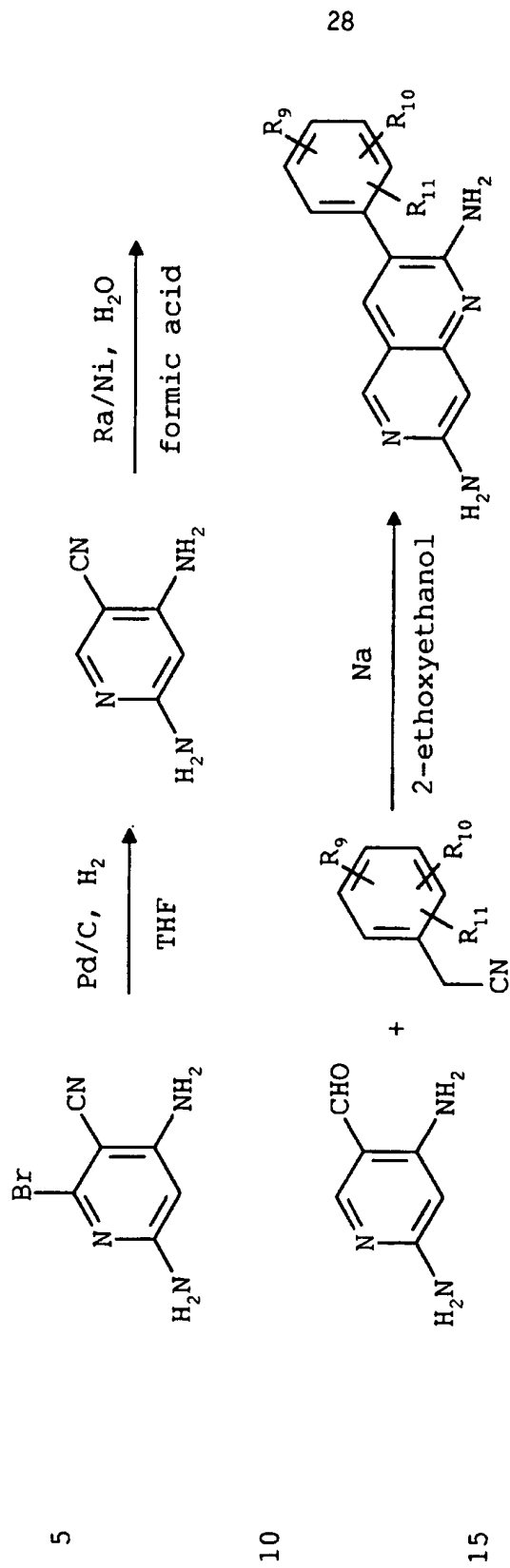
SCHEME II



SCHEME III

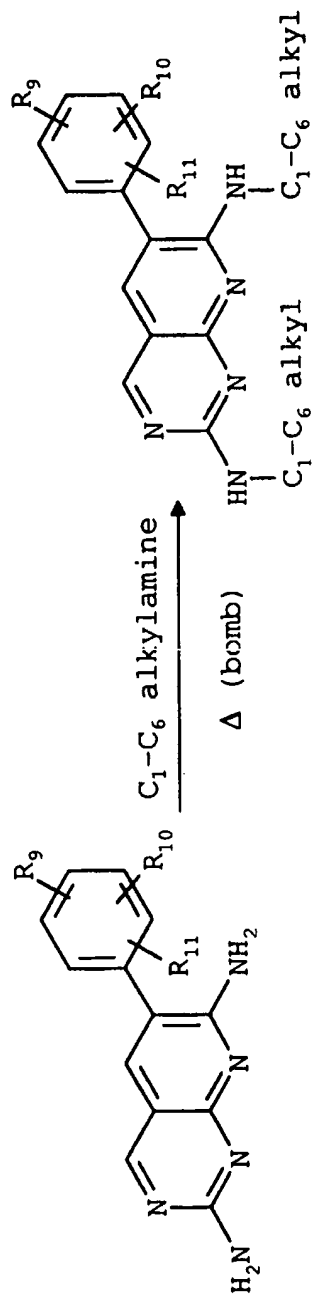


SCHEME IV



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SCHEME V



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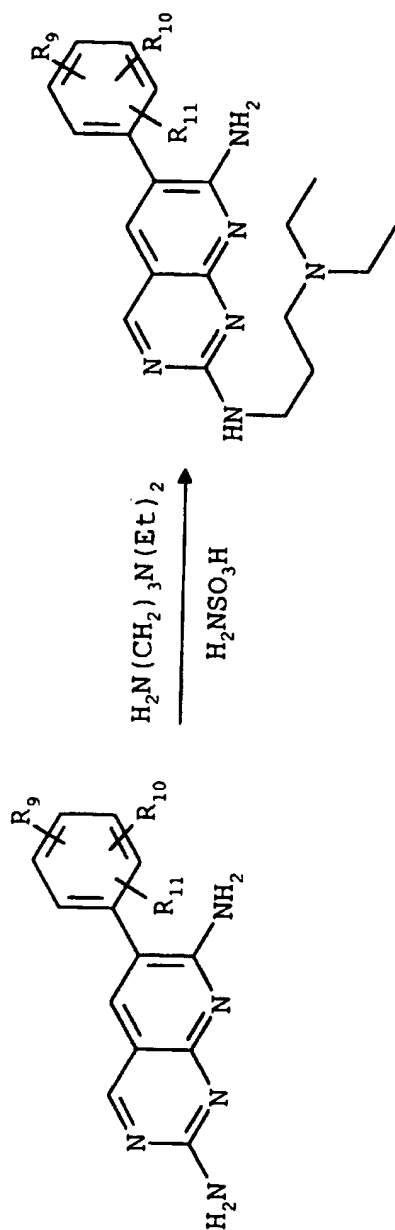
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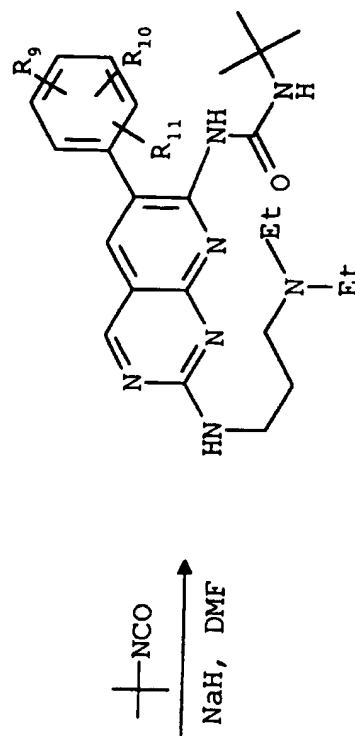
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SCHEME VI



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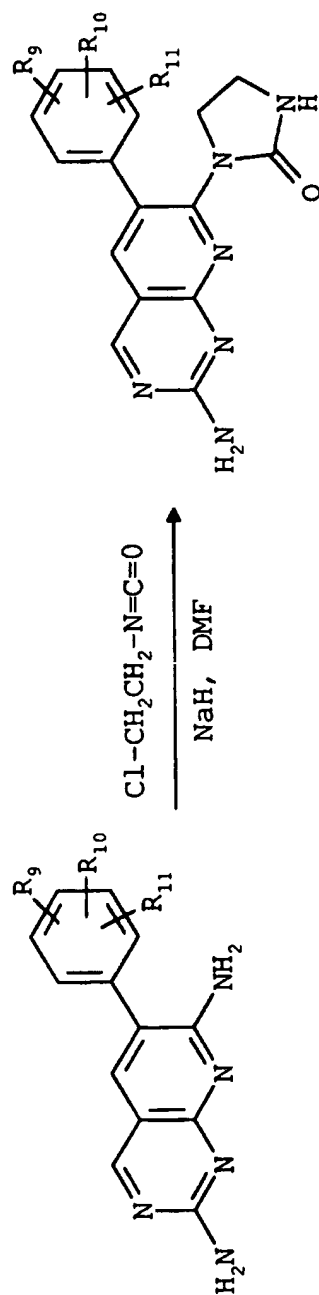


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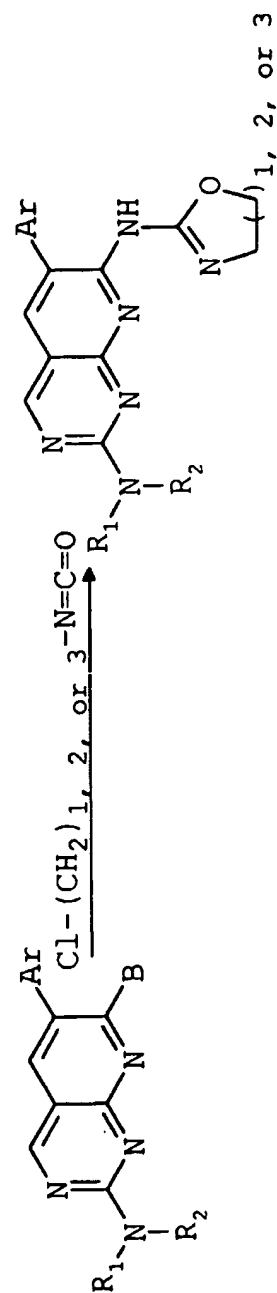
SCHEME VII



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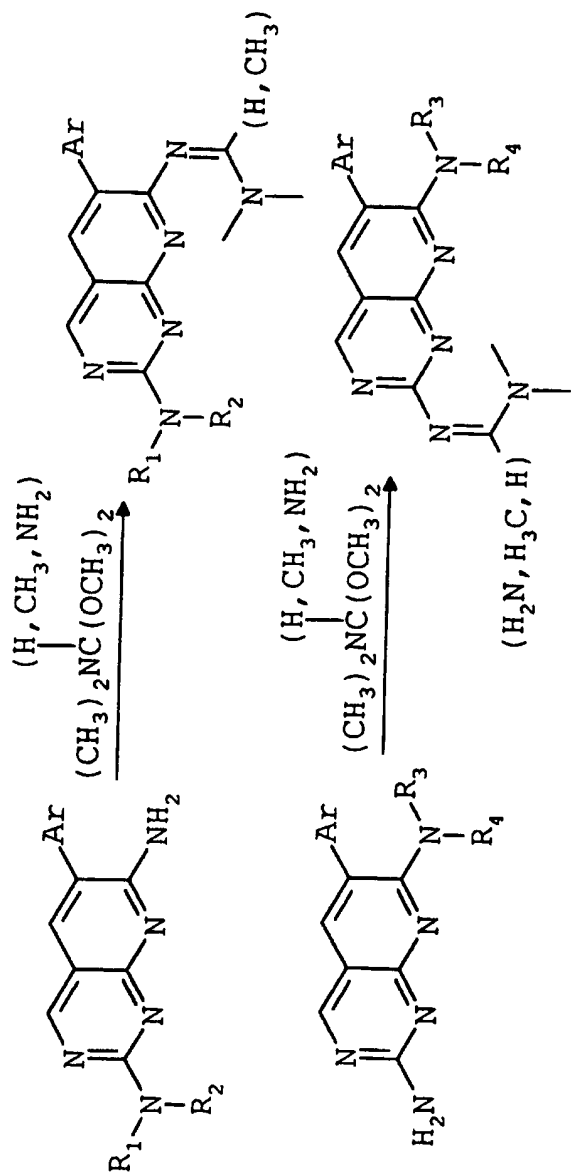
SCHEME VIIa



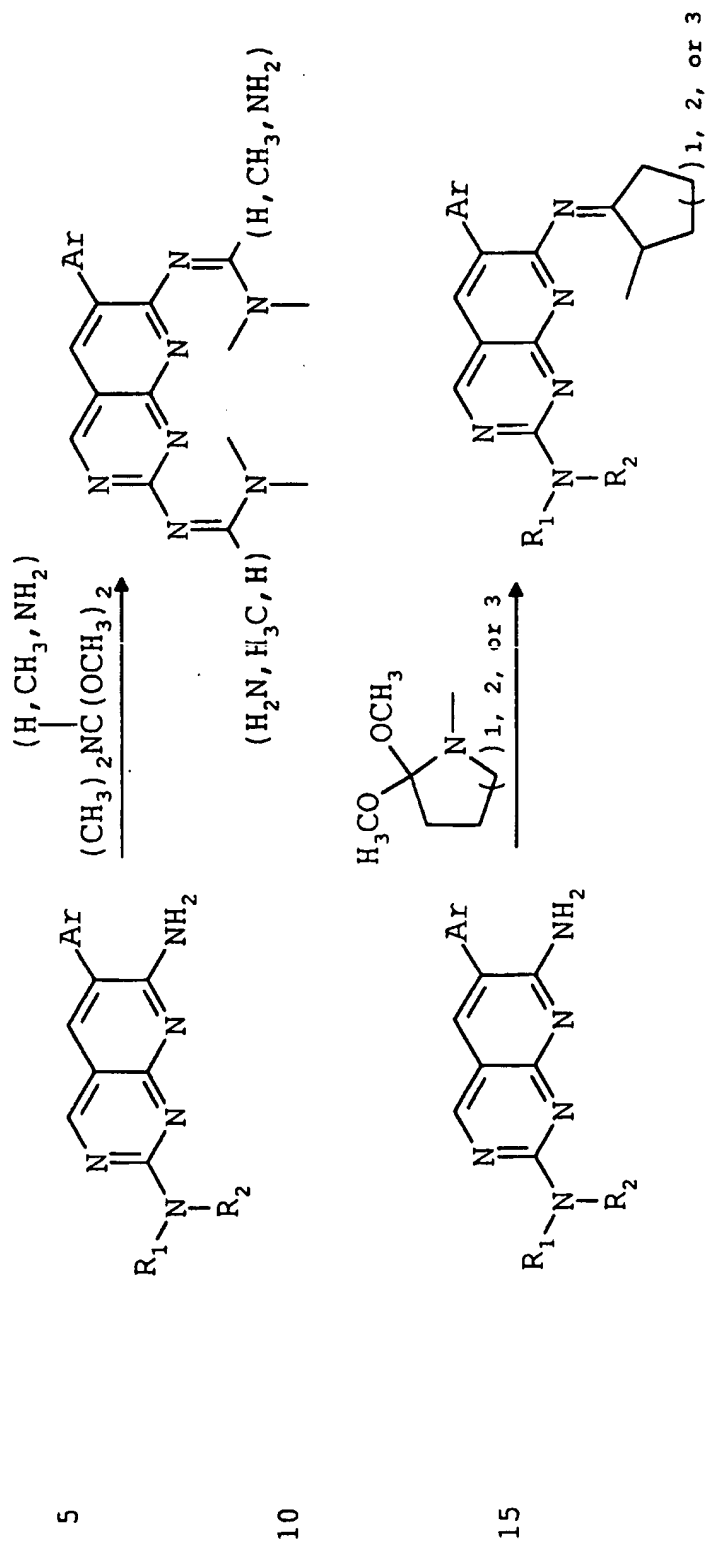
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SCHEME VIII

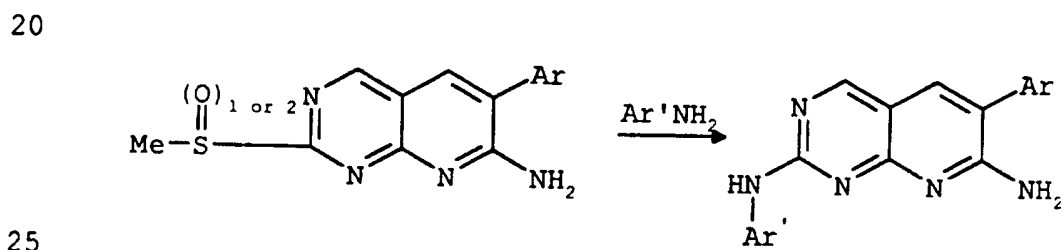
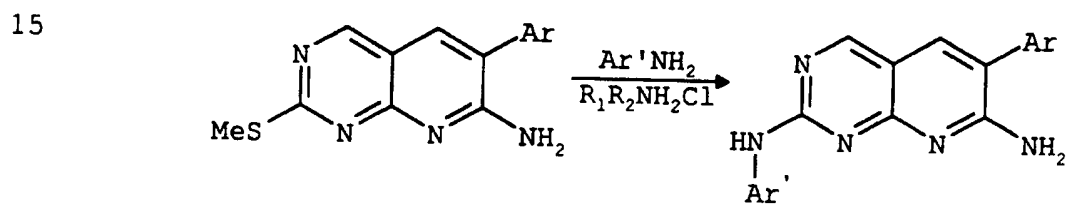
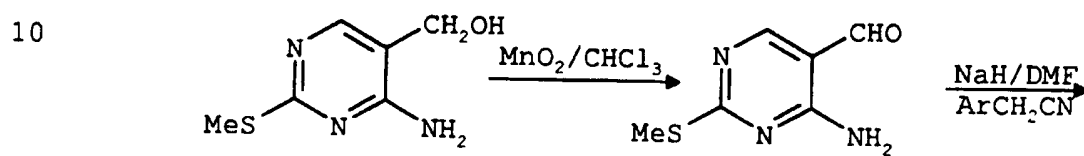
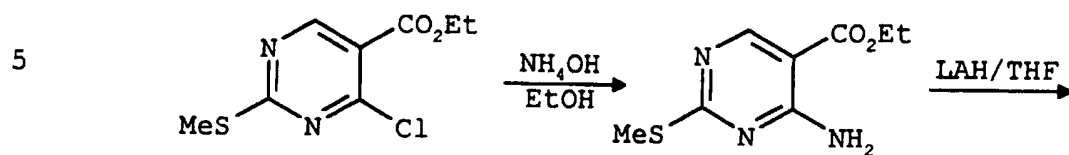


SCHEME VIII (Continued)



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SCHEME IX

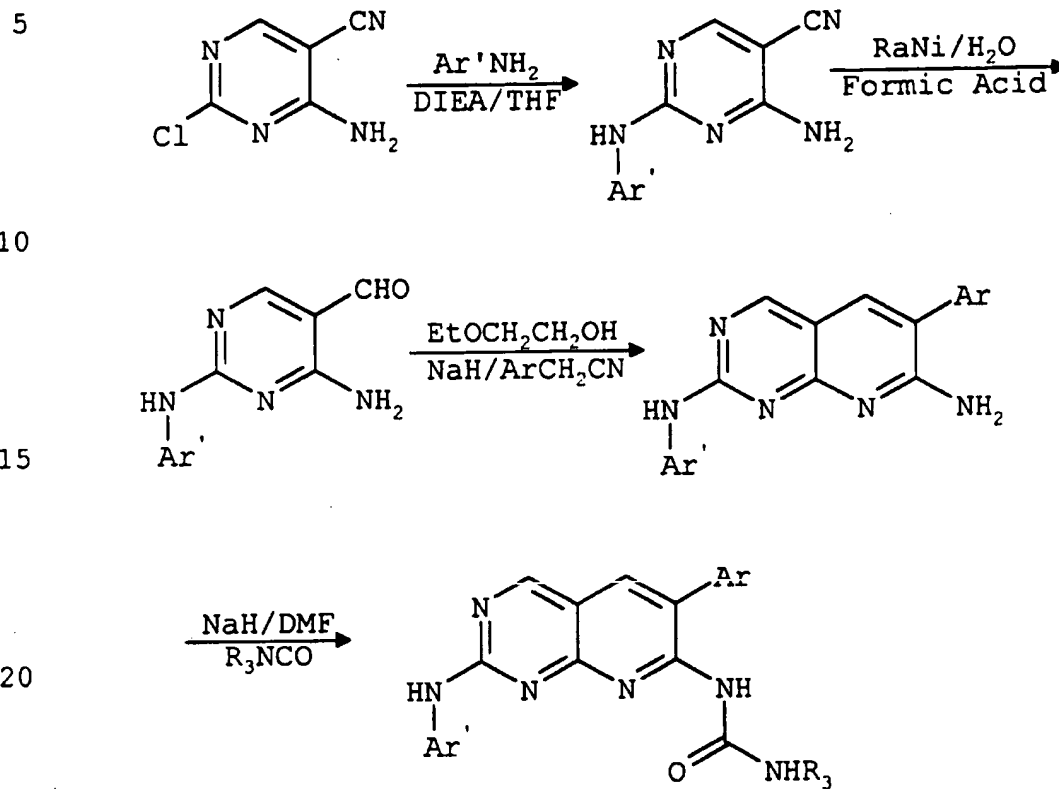


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SCHEME X



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The compounds of Formula I are valuable inhibitors of protein tyrosine kinases and possess therapeutic value as cellular antiproliferative agents for the treatment of proliferative disorders. These compounds are potent inhibitors of one or more of the protein kinases, PDGF, FGF, EGF, V-src, and C-src. The invention compounds are thus useful in treating atherosclerosis, restenosis, and cancer. Specific tumors to be treated with the compounds include small-cell lung carcinoma such as that described in An. Rev. Respir. Dis., 142:554-556 (1990); human breast cancer as described in Cancer Research, 52:4773-4778 (1992); low grade human bladder carcinomas of the type described in Cancer Research, 52:1457-1462 (1992); human colorectal cancer as discussed in J. Clin. Invest., 91:53-60 (1993); and in J. Surg. Res., 54:293-294 (1993). The compounds also are useful as antibiotics against bacteria such as *Streptococcus pneumoniae*. For instance, the compounds of Examples 9 and 18 exhibited activity against this Gram + bacterial strain when evaluated in standard in vitro assays. The compounds additionally are useful as herbicides against a wide variety of undesirable plants such as broad leaf weeds and grasses.

The compounds of the present invention can be formulated and administered in a wide variety of oral and parenteral dosage forms, including transdermal and rectal administration. It will be recognized to those skilled in the art that the following dosage forms may comprise as the active component, either a compound of Formula I or a corresponding pharmaceutically acceptable salt or solvate of a compound of Formula I.

A further embodiment of this invention is a pharmaceutical formulation comprising a compound of Formula I together with a pharmaceutically acceptable carrier, diluent, or excipient therefor. For preparing

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pharmaceutical compositions with the compounds of the present invention, pharmaceutically acceptable carriers can be either solid or liquid. Solid form preparations include powders, tablets, pills, capsules, cachets, suppositories, and dispersible granules. A solid carrier can be one or more substances which may also act as diluents, flavoring agents, binders, preservatives, tablet disintegrating agents, or an encapsulating material.

10 In powders, the carrier is a finely divided solid such as talc or starch which is in a mixture with the finely divided active component.

In tablets, the active component is mixed with the carrier having the necessary binding properties in suitable proportions and compacted in the shape and size desired.

The formulations of this invention preferably contain from about 5% to about 70% of the active compound. Suitable carriers include magnesium carbonate, magnesium stearate, talc, sugar, lactose, pectin, dextrin, starch, gelatin, tragacanth, methylcellulose, sodium carboxymethylcellulose, a low melting wax, cocoa butter, and the like. A preferred form for oral use are capsules, which include the formulation of the active compound with encapsulating material as a carrier providing a capsule in which the active component with or without other carriers, is surrounded by a carrier, which is thus in association with it. Similarly, cachets and lozenges are included. Tablets, powders, capsules, pills, cachets, and lozenges can be used as solid dosage forms suitable for oral administration.

For preparing suppositories, a low melting wax, such as a mixture of fatty acid glycerides or cocoa butter, is first melted and the active component is dispersed homogeneously therein, as by stirring. The

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molten homogenous mixture is then poured into convenient sized molds, allowed to cool, and thereby to solidify.

5 Liquid form preparations include solutions, suspensions, and emulsions, for example, water or water-propylene glycol solutions. For parenteral injection, liquid preparations can be formulated in solution in aqueous polyethylene glycol solution, isotonic saline, 5% aqueous glucose, and the like.

10 Aqueous solutions suitable for oral use can be prepared by dissolving the active component in water and adding suitable colorants, flavors, stabilizing and thickening agents as desired.

15 Aqueous suspensions suitable for oral use can be made by dispersing the finely divided active component in water with a viscous material, such as natural or synthetic gums, resins, methylcellulose, sodium carboxymethylcellulose, and other well-known suspending agents.

20 Also included are solid form preparations which are intended to be converted, shortly before use, to liquid form preparations for oral administration. Such liquid forms include solutions, suspensions, and emulsions. These preparations may contain, in addition to the active component, colorants, flavors, stabilizers, buffers, artificial and natural sweeteners, dispersants, thickeners, solubilizing agents, and the like. Waxes, polymers, and the like can be utilized to prepare sustained-release dosage forms. Also, osmotic pumps can be employed to deliver the active compound uniformly over a prolonged period.

30 The pharmaceutical preparations of the invention are preferably in unit dosage form. In such form, the preparation is subdivided into unit doses containing appropriate quantities of the active component. The

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unit dosage form can be a packaged preparation, the package containing discrete quantities of preparation, such as packeted tablets, capsules, and powders in vials or ampoules. Also, the unit dosage form can be a capsules, tablet, cachet, or lozenge itself, or it can be the appropriate number of any of these in packaged form.

The therapeutically effective dose of a compound of Formula I will generally be from about 1 mg to about 100 mg/kg of body weight per day. Typical adult doses will be about 50 to about 800 mg per day. The quantity of active component in a unit dose preparation may be varied or adjusted from about 0.1 mg to about 500 mg, preferably about 0.5 mg to 100 mg according to the particular application and the potency of the active component. The composition can, if desired, also contain other compatible therapeutic agents. A subject in need of treatment with a compound of Formula I will be administered a dosage of about 1 to about 500 mg per day, either singly or in multiple doses over a 24-hour period.

The compounds of this invention have been evaluated in standard assays which are utilized to determine inhibition of tyrosine kinase. One such assay was conducted as follows:

Purification of Epidermal Growth Factor Receptor Tyrosine Kinase

Human EGF receptor tyrosine kinase was isolated from A431 epidermoid carcinoma cells by the following methods. Cells were grown in roller bottles in 50% Delbuco's Modified Eagle and 50% HAM F-12 nutrient media (Gibco) containing 10% fetal calf serum. Approximately 10^9 cells were lysed in two volumes of buffer containing 20 mM 2-(4N-[2-hydroxyethyl]-piperazin-1-yl)ethanesulfonic acid, pH 7.4, 5 mM

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ethylene glycol bis(2-aminoethyl ether)
N,N,N',N'-tetraacetic acid, 1% Triton X-100, 10%
glycerol, 0.1 mM sodium orthovanadate, 5 mM sodium
fluoride, 4 mM pyrophosphate, 4 mM benzamide, 1 mM
5 dithiothreitol, 80 µg/mL aprotinin, 40 µg/mL leupeptin,
and 1 mM phenylmethylsulfonyl fluoride. After
centrifugation at 25,000 × g for 10 minutes, the
supernatant was equilibrated for 2 hours at 4°C with
10 mL of wheat germ agglutinin sepharose that was
10 previously equilibrated with 50 mM Hepes, 10% glycerol,
0.1% Triton X-100 and 150 mM NaCl, pH 7.5,
(equilibration buffer). Contaminating proteins were
washed from the resin with 1 M NaCl in equilibration
buffer, and the enzyme was eluted with 0.5 M
15 N-acetyl-1-D-glucosamine in equilibration buffer.

Determination of IC₅₀ Values

Enzyme assays for IC₅₀ determinations were
performed in a total volume of 0.1 mL, containing 25 mM
20 Hepes, pH 7.4, 5 mM MgCl₂, 2 mM MnCl₂, 50 µM sodium
vanadate, 5-10 ng of EGF receptor tyrosine kinase,
200 µM of a substrate peptide, e.g., (Ac-Lys-His-Lys-
Lys-Leu-Ala-Glu-Gly-Ser-Ala-Tyr⁴⁷²-Glu-Glu-Val-NH₂),
(Wahl M.I., et al., J. Biol. Chem., 265:3944-3948
25 (1990)), 10 µM ATP containing 1 µCi of [³²P]ATP, and
incubated for 10 minutes at room temperature. The
reaction was terminated by the addition of 2 mL of
75 mM phosphoric acid and passed through a 2.5-cm
phosphocellulose filter disc to bind the peptide. The
30 filter was washed five times with 75 mM phosphoric acid
and placed in a vial along with 5 mL of scintillation
fluid (Ready gel Beckman).

PDGF and FGF Receptor Tyrosine Kinase Assays

35 Full length cDNAs for the mouse PDGF-β and human
FGF-1 (flg) receptor tyrosine kinases were obtained

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from J. Escobedo and prepared as described in J. Biol. Chem., 262:1482-1487 (1991), and PCR primers were designed to amplify a fragment of DNA that codes for the intracellular tyrosine kinase domain. The fragment was melded into a baculovirus vector, cotransfected with AcMNPV DNA, and the recombinant virus isolated. SF9 insect cells were infected with the virus to overexpress the protein, and the cell lysate was used for the assay. The assay was performed in 96-well plates (100 μ L/incubation/well), and conditions were optimized to measure the incorporation of 32 P from γ 32 P-ATP into a glutamate-tyrosine co-polymer substrate. Briefly, to each well was added 82.5 μ L of incubation buffer containing 25 mM Hepes (pH 7.0), 150 mM NaCl, 0.1% Triton X-100, 0.2 mM PMSF, 0.2 mM Na₃VO₄, 10 mM MnCl₂, and 750 μ g/mL of Poly (4:1) glutamate-tyrosine followed by 2.5 μ L of inhibitor and 5 μ L of enzyme lysate (7.5 μ g/ μ L FGF-TK or 6.0 μ g/ μ L PDGF-TK) to initiate the reaction. Following a 10 minute incubation at 25°C, 10 μ L of γ 32 P-ATP (0.4 μ Ci plus 50 μ M ATP) was added to each well and samples were incubated for an additional 10 minutes at 25°C. The reaction was terminated by the addition of 100 μ L of 30% trichloroacetic acid (TCA) containing 20 mM sodium pyrophosphate and precipitation of material onto glass fiber filter mats (Wallac). Filters were washed three times with 15% TCA containing 100 mM sodium pyrophosphate and the radioactivity retained on the filters counted in a Wallac 1250 Betaplate reader. Nonspecific activity was defined as radioactivity retained on the filters following incubation of samples with buffer alone (no enzyme). Specific enzymatic activity was defined as total activity (enzyme plus buffer) minus nonspecific activity. The concentration of a compound that

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inhibited specific activity by 50% (IC_{50}) was determined based on the inhibition curve.

V-src and C-src Kinase Assays

5 V-src or C-src kinase is purified from baculovirus infected insect cell lysates using an antipeptide monoclonal antibody directed against the N-terminal 2-17 amino acids. The antibody, covalently linked to 0.65- μ m latex beads, is added to a suspension of insect
10 cell lysis buffer comprised of 150 mM NaCl, 50 mM Tris pH 7.5, 1 mM DTT, 1% NP-40, 2 mM EGTA, 1 mM sodium vanadate, 1 mM PMSF, 1 μ g/mL each of leupeptin, pepstatin, and aprotinin. Insect cell lysate containing either the c-src or v-src protein is
15 incubated with these beads for 3-4 hours at 4°C with rotation. At the end of the lysate incubation, the beads are rinsed 3 times in lysis buffer, resuspended in lysis buffer containing 10% glycerol, and frozen. These latex beads are thawed, rinsed three times in
20 assay buffer which is comprised of 40 mM tris pH 7.5, 5 mM $MgCl_2$, and suspended in the same buffer. In a Millipore 96-well plate with a 0.65 μ m polyvinylidene membrane bottom are added the reaction components: 10- μ L v-src or c-src beads, 10 μ L of 2.5 mg/mL poly
25 GluTyr substrate, 5 μ M ATP containing 0.2 μ Ci labeled 32 P-ATP, 5 μ L DMSO containing inhibitors or as a solvent control, and buffer to make the final volume 125 μ L. The reaction is started at room temperature by addition of the ATP and quenched 10 minutes later by the
30 addition of 125 μ L of 30% TCA, 0.1 M sodium pyrophosphate for 5 minutes on ice. The plate is then filtered and the wells washed with two 250- μ L aliquots of 15% TCA, 0.1 M pyrophosphate. The filters are punched, counted in a liquid scintillation counter, and
35 the data examined for inhibitory activity in comparison to a known inhibitor such as erbstatin. The method is

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described more fully in J. Med. Chem., 37:598-609 (1994).

Cell Culture

5 Rat aorta smooth muscle cells (RASMC) were isolated from the thoracic aorta of rats and explanted according to the method of Ross, J. Cell. Biol., 30:172-186 (1971). Cells were grown in Dulbecco's modified Eagle's medium (DMEM, Gibco) containing 10% fetal calf serum (FBS, Hyclone, Logan, Utah), 1% glutamine (Gibco) and 1% penicillin/streptomycin (Gibco). Cells were identified as smooth muscle cells by their "hill and valley" growth pattern and by fluorescent staining with a monoclonal antibody specific for SMC μ -actin (Sigma). RASMC were used between passages 5 and 20 for all experiments. Test compounds were prepared in dimethylsulfoxide (DMSO) in order to achieve consistency in the vehicle and to ensure compound solubility. Appropriate DMSO controls were simultaneously evaluated with the test compounds.

[³H]-Thymidine Incorporation Assay

RASMC were plated into a 24-well plate (30,000 cells/well) in DMEM with 10% FBS. After 4 days, cells reached confluence and were made quiescent by incubation in DMEM/F12 medium (Gibco) containing 0.2% FBS for another 2 days. DNA synthesis was induced by incubating cells for 22 hours with either PDGF-BB, bFGF, or FBS, plus test compound in 0.5 mL/well serum-substituted medium (DMEM/F12 + 1% CPSR-2 from Sigma). After 18 hours, 0.25 μ Ci/well [³H]-thymidine was added. Four hours later, the incubation was stopped by removing the radioactive media, washing the cells twice with 1 mL cold phosphate-buffered saline, and then washing 2 times with cold 5% trichloroacetic acid. The acid-insoluble

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fraction was lysed in 0.75 mL 0.25 N NaOH and the radioactivity determined by liquid scintillation counting. IC₅₀ values were determined graphically.

5 **PDGF Receptor Autophosphorylation**

RASMC were grown to confluency in 100 mm dishes. Growth medium was removed and replaced with serum-free medium and cells were incubated at 37°C for an additional 24 hours. Test compounds were then added directly to the medium and cells incubated for an additional 2 hours. After 2 hours, PDGF-BB was added at a final concentration of 30 ng/mL for 5 minutes at 37°C to stimulate autophosphorylation of the PDGF receptor. Following growth factor treatment, the medium was removed, and cells were washed with cold phosphate-buffered saline and immediately lysed with 1 mL of lysis buffer (50 mM HEPES[pH 7.5], 150 mM NaCl, 10% glycerol, 1% Triton X-100, 1 mM EDTA, 1 mM EGTA, 50 mM NaF, 1 mM sodium orthovanadate, 30 mM p-nitrophenyl phosphate, 10 mM sodium pyrophosphate, 1 mM phenylmethyl sulfonyl fluoride, 10 µg/mL aprotinin, and 10 µg/mL leupeptin). Lysates were centrifuged at 10,000 × g for 10 minutes. Supernatants were incubated with 10 µL of rabbit anti-human PDGF type AB receptor antibody (1:1000) for 2 hours. Following the incubation, protein-A-sepharose beads were added for 2 hours with continuous mixing, and immune complexes bound to the beads washed 4 times with 1 mL lysis wash buffer. Immune complexes were solubilized in 30 µL of Laemmli sample buffer and electrophoresed in 4-20% SDS polyacrylamide gels. Following electrophoresis, separated proteins were transferred to nitrocellulose and immunoblotted with anti-phosphotyrosine antiserum. Following incubation with [¹²⁵I]-protein-A, the levels of tyrosine phosphorylated proteins were detected by phosphorimage

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analysis and protein bands quantitated via densitometry. IC₅₀ values were generated from the densitometric data.

5 The following Tables I and II present biological data for representative compounds of the invention when analyzed in the foregoing assays.

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TABLE I. Inhibition of Protein Tyrosine Kinases (μM
 IC_{50} or (% Inhibition) at 50 μM)
 (Page 1 of 3)

	Example	PDGF	FGF	EGF	V-src	C-src
5	1	21.2	2.99		(-2.4%)	0.21
	2	10.2	1.60	(52.3%)	(27.4%)	19.5
	3	1.25	0.140	1.17	(46.8%)	0.22
	4	(31.9%)	(21.5%)	(36.65%)	(3.1%)	(33.6%)
10	5	0.466	1.40	0.928	(23.3%)	0.407
	6	0.34	0.397	0.457	(39.8%)	0.11
	7	(33.5%)	17.9	(25.15%)	(7.6%)	2.3
	9	25.1	10.56			18.3
15	13	(18.2%)	30.3		(21.2%)	(15.9%)
	16	10.72	9.21	7.08	(10.3%)	1.38
	17	27.0	4.50	7.22	(5.3%)	2.76
	18	21.3	1.19	18.2	(21.4%)	0.514
20	19	(47.7%)	16.93	(26.1%)	(5.2%)	(52.8%)
	20	46.1	2.38		(51.7%)	0.748
	21	0.66	0.0824	6.97	(49.4%)	0.073
	22	1.3	0.128	(90.4%)	(46.9%)	0.077
25	23	4.51	0.291	(104.8%)	(10.2%)	0.613
	24	11.38	7.29	(58.3%)	(15.6%)	0.214
	25	6.04	11.82	(57.55%)	(0.0%)	0.207
	26	1.08	0.116			0.0395
30	28	0.676	0.075			0.117
	30	1.78	0.264			(46.8%)
	32	0.415	0.0739			5.0
	34	0.349	0.0552			0.011
35	35	2.08	(97.9%)			
	36	22.88	0.523			0.184
	37	0.263	0.0401			(106.5%)
	38	0.360	0.047			0.019
40	39	1.98	0.125			0.021
	40	0.697	0.0574			
	41	0.793	0.139			0.086
	42	0.624	0.108			0.032
45	43	0.405	0.091			0.011
	44	1.55	0.196			0.023
	45	1.85	0.198			0.04
	47	6.17	0.637			0.161
50	48	5.32	0.613			0.26
	49	0.420	0.0535			0.024
	50	2.60	0.305			
	51	0.573	0.084			0.10
55	52	0.468	0.051			0.032
	53	7.08	0.693			0.153
	54	0.231	0.0954			
	58	19.0	3.46			(109.8%)
	59	0.838	0.072			0.085

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TABLE I. Inhibition of Protein Tyrosine Kinases (μM
 IC_{50} or (% Inhibition) at 50 μM)
 (Page 2 of 3)

	Example	PDGF	FGF	EGF	V-src	C-src
5	60	35.9	13.0			1.57
	61	45.6	7.85			0.764
	63	7.01	0.543			1.78
	64	(13.0%)	(23.8%)			(0.0%)
	65	(29.6%)	17.0			(95.0%)
10	66	5.19	1.28			3.42
	67	12.05	1.39			1.56
	69	15.55	1.96			4.66
	70	31.35	2.59			0.929
	78	32.9	4.01			3.99
15	79	17.78	8.09	(60.93%)		
	80	(22.9%)	10.2			
	81				(-20.3%)	(67.5%)
	82	4.67	3.71			(77.6%)
	83	42.5	1.98		(-9.8%)	(53.6%)
20	84	2.26	0.162			3.82
	85	7.63	0.129			4.46
	86	2.96	0.114			1.41
	87	1.88	0.118			(92.7%)
	88	0.711	0.148	(34.4%)		0.213
25	89	0.857	0.111			0.036
	90	8.01	11.46	22.75	(16.8%)	1.63
	92	(33.1%)	2.01		(-10.1%)	(44.5%)
	93	6.05	0.343			4.17
	94	(11.5%)	17.6			
30	95	41.6	0.605			(0.0%)
	96	27.4	3.84			
	97	1.73	0.34			(28.9%)
	98	(34.3%)	1.80			(0.5%)
	99	(15.5%)	0.708			(17.1%)
35	100	(22.3%)	(27.1%)		(6.0%)	(46.6%)
	101	4.48	11.22			19.3
	102	(44.4%)	3.11		(-8.2%)	(0.8%)
	103	19.6	0.300			36.4
	104	36.7	5.32			
40	105	0.618	0.181			0.214
	106	4.8	0.361			0.236
	107	(20.5%)	(37.2%)		(1.4%)	(37.0%)
	108	13.7	4.48			5.66
	109	(23.6%)	(10.3%)			
45	110	11.5	12.8			(27.5%)
	111	23.3	(47.7%)		(-26.4%)	(15.7%)
	112	1.26	0.128			0.077
	113	1.09	0.077			0.078
	114	23.9	19.2			

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TABLE I. Inhibition of Protein Tyrosine Kinases (μM IC_{50} or (% Inhibition) at 50 μM)
(Page 3 of 3)

	Example	PDGF	FGF	EGF	V-src	C-src
5	115	2.63	1.24			0.024
	116	0.804	0.335			0.098
	117	2.79	0.135			(100%)
	118	1.92	0.126			
	119	62.4	7.71			
10	120	3.84	3.27			42.7
	121	(21.8%)	0.142			
	122	1.46	0.171			
	123	0.26	0.045			0.029
	124	0.253	0.059			0.026

TABLE II. Cellular Assays ($\text{IC}_{50} = \mu\text{M}$)

	Example	Inhibition of PDGF Stimulated Receptor Auto Phosphorylation ($\text{IC}_{50} = \mu\text{M}$)	Inhibition of Growth Factor Stimulated Uptake of [^3H]-thymidine ($\text{IC}_{50} = \mu\text{M}$)
20	3	0.97	2.7 (PDGF), 0.9 (FGF)
	124	0.245	0.55 (PDGF), 0.93 (FGF)
	51	0.365	
	123	0.296	< 0.30 (PDGF), 0.32 (FGF)
	52	0.241	0.45 (PDGF), 0.40 (FGF)
25	69	6.46	
	113	1.1	
	89	1.63	
	59	1.19	
	67	9.42	
30	115	5.13	
	66	5.29	
	116	0.91	
	28	1.38	
	114	15.86	
35	112	1.08	
	22	3.73	
	21	1.8	
	6	0.35	
40	90		>10 (PDGF), 20.0 (FGF)

The invention compounds are especially useful for treating restenosis following balloon angioplasty of

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occluded arteries. Restenosis occurs in about 40% of individuals undergoing angioplasty of calcified arteries and is a major problem associated with this form of treatment of patients suffering from such cardiac condition. The invention compounds demonstrate good activity when evaluated in standard tests such as described below.

Balloon Angioplasty of Rat Carotid Arteries

Male Sprague-Dawley rats (350-450 g) are divided into two treatment groups: one group of rats (n = 10) are treated with drug (100 mg/kg PO, BID) and the second group received vehicle (2 mL/kg PO, BID (n = 10)). All animals were pretreated for 2 days prior to surgery and continued to receive daily drug treatment postinjury until sacrificed.

Balloon injury in rat carotid arteries were performed according to the following protocol. Rats were anesthetized with Telazol (0.1 mL/100 g IM), and the carotid artery exposed via an anterior mid-line incision on the neck. The carotid artery was isolated at the bifurcation of the internal and external carotid arteries. A 2F embolectomy catheter was inserted in the external carotid artery and advanced down the common carotid to the level of the aortic arch. The balloon was inflated and the catheter is dragged back to the point of entry and then deflated. This procedure is repeated two more times. The embolectomy catheter was then removed and the external carotid artery was ligated leaving flow intact through the internal carotid artery. Surgical incisions were closed, and the animal was allowed to recover from anesthesia before being returned to its home cage.

At various time points postinjury animals were euthanized with CO₂ inhalation, and the carotid artery was perfusion fixed and processed for histologic

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examination. Morphologic determination of lesion size was made by measuring the area of the carotid artery intima expressed as a ratio of the media in individual animals. Up to 16 sections were prepared from each animal to give a uniform representation of lesion size down the length of the carotid artery. The cross-sectional areas of the blood vessels were quantified using an image analysis program from Princeton Gamma Tech (Princeton, New Jersey).

The following examples illustrate methods for preparing intermediate and final products of the invention. They are not intended to limit the scope of the invention. Mixtures of solvents are volume/volume.

EXAMPLE 1

2,7-Diamino-6-(2,6-dichlorophenyl)-pyrido[2,3-d]-pyrimidine

(Prepared by the method of U.S. Patent Number 3,534,039). To a solution of sodium 2-ethoxyethoxide prepared from 0.14 g of sodium and 60 mL of 2-ethoxyethanol was added 2.07 g of 2,4-diamino-5-pyrimidinecarboxaldehyde and 2.79 g of 2,6-dichlorophenylacetonitrile. The mixture is heated at reflux for 4 hours, cooled, and the insoluble product washed with diethylether to give 2,7-diamino-6-(2,6-dichlorophenyl)-pyrido[2,3-d]pyrimidine, mp 325-332°C (MS).

EXAMPLE 2

1-tert-Butyl-3-[7-(3-tert-butylureido)-6-(2,6-dichlorophenyl)-pyrido[2,3-d]pyrimidin-2-yl]urea

To a slurry of 3.0 g of 2,7-diamino-6-(2,6-dichlorophenyl)-pyrido[2,3-d]pyrimidine from above in 45 mL of DMF is added 0.48 g sodium hydride (50% in mineral oil) portionwise. The mixture is stirred for

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1 hour, 1.0 g of tert-butylisocyanate added, and the reaction mixture stirred at ambient temperature for 16 hours. The reaction mixture is filtered to remove a small amount of insoluble material and the filtrate
5 diluted with 500 mL of water. The insoluble product is collected by filtration, washed with water, then ether, and dried in air on the filter. The product is purified by silica gel chromatography eluting with a gradient of 0-1% methanol in chloroform to afford,
10 after crystallization from ethanol, 0.7 g of 1-tert-butyl-3-[7-(3-tert-butylureido)-6-(dichlorophenyl)-pyrido[2,3-d]pyrimidin-2-yl]urea, mp 200°C dec.

Analysis calculated for $C_{23}H_{22}Cl_2N_7O_2 \cdot 0.1 H_2O$:
15 Theory: C, 54.57; H, 5.42; N, 19.37; H_2O , 0.36.
Found: C, 54.05; H, 5.43; N, 19.08; H_2O , 0.37.

EXAMPLE 3

20 1-[2-Amino-6-(2,6-dichlorophenyl)-pyrido[2,3-d]-pyrimidin-7-yl]-3-tert-butylurea

Continued elution from Example 2 above afforded 1.5 g of 1-[2-amino-6-(2,6-dichlorophenyl)-pyrido[2,3-d]pyrimidin-7-yl]-3-tert-butylurea after crystallization from ethanol, mp 335°C.

25 Analysis calculated for $C_{18}H_{18}Cl_2N_6O \cdot 0.5 H_2O$:
Theory: C, 52.18; H, 4.62; N, 20.28; H_2O , 2.17.
Found: C, 51.90; H, 4.56; N, 20.01; H_2O , 2.39.

EXAMPLE 4

30 1-tert-Butyl-3-[7-(3-tert-butylureido)-6-o-tolyl-pyrido[2,3-d]pyrimidin-2-yl]urea

A suspension of 0.5 g of 2,7-diamino-6-o-tolyl-pyrido[2,3-d]pyrimidine, prepared as described above in Example 1, in 10 mL of dimethylformamide is reacted
35 with 0.16 g of 60% sodium hydride and stirred at ambient temperature for 1.5 hours. To the suspension

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is added 0.49 mL of t-butyliisocyanate and the mixture stirred overnight at ambient temperature. The reaction mixture is filtered to remove insoluble salts and the filtrate evaporated under reduced pressure. The residue is diluted with water, the insoluble crude product collected by filtration and dried in vacuo. Crystallization from a hexane:ethyl acetate:dichloromethane mixture (3:2:5 v/v/v) afforded the title compound, mp 209-212°C dec.

Analysis calculated for $C_{24}H_{31}N_7O_2 \cdot 0.3 H_2O$:
Theory: C, 63.36; H, 7.00; N, 21.55.
Found: C, 63.37; H, 6.92; N, 21.16.

EXAMPLE 5

15 1-[2-Amino-6-o-tolyl-pyrido[2,3-d]pyrimidin-7-yl]-3-tert-butylurea

Prepared as described above in Example 2 starting from 2,7-diamino-6-o-tolyl-pyrido[2,3-d]pyrimidine to afford the title compound 1-[2-amino-6-o-tolyl-pyrido[2,3-d]pyrimidin-7-yl]-3-tert-butylurea, mp 285-290°C dec; MS (CI).

EXAMPLE 6

25 1-[2-Amino-6-(2,6-dimethylphenyl)-pyrido[2,3-d]pyrimidin-7-yl]-3-tert-butylurea

Prepared as described above in Example 2 starting from 2,7-diamino-6-(2,6-dimethylphenyl)-pyrido[2,3-d]pyrimidine to give the title compound 1-[2-amino-6-(2,6-dimethylphenyl)-pyrido[2,3-d]pyrimidin-7-yl]-3-tert-butylurea, mp 203-205°C dec; CIMS (1% ammonia in methane) 365 (M + 1, 50), 366 (M + 2, 10), 84 (100).

EXAMPLE 7

35 N-[2-Acetylamino-6-(2,6-dichlorophenyl)-pyrido[2,3-d]pyrimidin-7-yl]-acetamide

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A mixture of 10 g of 2,7-diamino-6-(2,6-dichlorophenyl)-pyrido[2,3-d]pyrimidine prepared as described in Example 1 in 100 mL of acetic anhydride was refluxed for 2 hours. The reaction mixture was
5 allowed to cool to room temperature and the excess acetic anhydride removed under vacuum. The residue was dissolved in ethanol, charcoaled, filtered, and cooled overnight at 0°C. The insoluble crude product was collected by filtration, washed with diethylether and
10 dried in vacuo. The crude product was crystallized from boiling ethyl acetate using charcoal to give 2.7 g of an impure product, which was further purified by slurrying in hot ethyl acetate and collecting the insoluble pure product (1.2 g), mp 223-225°C.
15 Analysis calculated for $C_{17}H_{13}Cl_2N_5O_2$:
Theory: C, 52.32; H, 3.36; N, 17.95.
Found: C, 51.92; H, 3.43; N, 17.78.

EXAMPLE 8

20 2-Amino-6-phenyl-pyrido[2,3-d]pyrimidin-7-ol

To a solution of 2 L of concentrated HCl and 1 L of water is added 300 g of the disulfate salt of 2,7-diamino-6-phenylpyrido[2,3-d]pyrimidine and the resulting mixture refluxed with stirring overnight.
25 The reaction mixture is cooled in an ice bath, filtered, and the insoluble product washed with water, followed by ethanol to give 149 g of the title compound 2-amino-6-phenyl-pyrido[2,3-d]pyrimidin-7-ol, mp 390-395°C (darkens slowly above 350°C).

30

EXAMPLE 9

N⁷-Butyl-6-phenyl-pyrido[2,3-d]pyrimidine-2,7-diamine

To a mixture of 23.8 g of 2-amino-6-phenyl-pyrido-
[2,3-d]pyrimidin-7-ol prepared above in Example 8,
35 250 mL of dichloromethane, and 77.5 mL of dimethylformamide was added dropwise with cooling 36 mL

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of thionyl chloride keeping the temperature below 15°C. Following complete addition, the suspension was heated to reflux with stirring for 5 hours. The solvents were removed in vacuo maintaining the temperature below 60°C. The resulting solid was added with cooling to 250 mL of n-butylamine and the suspension refluxed for 6 hours with stirring. The reaction mixture was allowed to cool to room temperature, filtered, and the volatile components of the filtrate removed on a rotary evaporator in vacuo. The viscous oil was partitioned between diethyl ether and water, the layers were separated, and the ethereal layer was washed with water. The organic layer was dried over anhydrous magnesium sulfate, filtered, and evaporated. The residue was partitioned between diethyl ether and dilute 1N HCl. The aqueous layer was washed three times with diethylether and made alkaline to pH 12 by addition of sodium hydroxide. The solid product was collected by filtration and dried in vacuo to afford 6.5 g of the title compound N⁷-butyl-6-phenyl-pyrido[2,3-d]pyrimidine-2,7-diamine, mp 174-181°C dec.

Analysis calculated for C₁₇H₁₉N₅:
Theory: C, 69.60; H, 6.53; N, 23.87.
Found: C, 69.53; H, 6.63; N, 24.37.

EXAMPLE 10

2-Amino-6-(4-methoxyphenyl)-pyrido[2,3-d]pyrimidin-7-ol

The title compound was prepared as described above in Example 8 starting from 2,7-diamino-6-(4-methoxyphenyl)-pyrido[2,3-d]pyrimidine (U.S. Patent Number 3,534,039), mp 380-385°C dec.

Analysis calculated for C₁₄H₁₂N₄O₂·0.75 H₂O:
Theory: C, 59.90; H, 4.42; N, 19.88.
Found: C, 60.10; H, 4.32; N, 19.64.

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EXAMPLE 11

N'-(7-Chloro-6-(4-methoxyphenyl)-pyrido[2,3-d]-pyrimidin-2-yl)-N,N-dimethyl-formamidine

To a mixture of 67.0 g of 2-amino-6-(4-methoxy-phenyl)-pyrido[2,3-d]pyrimidin-7-ol from Example 10, 1 L of dichloromethane, and 155 mL of dimethylformamide was added dropwise with cooling 72 mL of thionyl chloride keeping the temperature below 15°C. The suspension was heated to reflux with stirring for 6 hours. The reaction mixture was filtered and the filtrate evaporated in vacuo maintaining the temperature below 60°C. The resulting residue was dissolved in ice water and aqueous sodium hydroxide added with ice. The product was taken up in chloroform, washed with water, dried over anhydrous potassium carbonate, and evaporated. The residue was slurried with acetonitrile and the insoluble product collected by filtration to afford 31 g of the title compound N'-(7-chloro-6-(4-methoxyphenyl)-pyrido[2,3-d]pyrimidin-2-yl)-N,N-dimethyl-formamidine. The product was used in the next step without further purification.

EXAMPLE 12

2-Amino-7-chloro-6-(4-methoxyphenyl)-pyrido[2,3-d]-pyrimidine

A mixture of 10 g of N'-(7-chloro-6-(4-methoxyphenyl)-pyrido[2,3-d]pyrimidin-2-yl)-N,N-dimethyl-formamidine from Example 11 and 500 mL of 95% ethanol was refluxed for 3 hours. The solution was concentrated in vacuo and the precipitate collected by filtration. Crystallization from ethanol afforded 2.7 g of the title compound 2-amino-7-chloro-6-(4-methoxyphenyl)-pyrido[2,3-d]pyrimidine, mp 275-280°C dec.

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Analysis calculated for $C_{14}H_{11}N_4ClO$:

Theory: C, 58.64; H, 3.87; N, 19.54.

Found: C, 58.70; H, 3.94; N, 19.51.

5

EXAMPLE 13

6-(4-Methoxyphenyl)-N⁷-methyl-pyrido[2,3-d]-
pyrimidine-2,7-diamine

10 A mixture of 3.4 g of 2-amino-7-chloro-6-(4-methoxyphenyl)-pyrido[2,3-d]pyrimidine from Example 12, 40 mL of anhydrous methylamine, and 10 mL of methanol were heated in a bomb on a steam bath for 4 hours. After cooling, the suspension was washed out of the bomb with 50 mL of methanol/water (50:50) and the solvents were evaporated in vacuo. The solid
15 residue was slurried with 50 mL of water, filtered, and crystallized from ethanol to afford 2.2 g of the title compound 6-(4-methoxyphenyl)-N⁷-methyl-pyrido[2,3-d]-pyrimidine-2,7-diamine, mp 270-275°C dec.

Analysis calculated for $C_{15}H_{15}N_5O$:

20 Theory: C, 64.03; H, 5.37; N, 24.90.

Found: C, 63.82; H, 5.17; N, 24.94.

EXAMPLE 14

2,4-Diamino-5-cyanopyridine

25 A suspension of 21.3 g of 6-bromo-2,4-diamino-5-cyanopyridine (JACS, 80:2838-2840 (1958)) and 1 g of 20% palladium on charcoal in 250 mL of tetrahydrofuran was shaken in a Parr apparatus under an atmosphere hydrogen. After 2 hours, the reaction was stopped and
30 10 g of potassium acetate and 50 mL of methanol added. The reaction was recharged with hydrogen and shaken for 18 hours. The solvents were removed under reduced pressure and the residue crystallized from isopropyl alcohol to afford the title compound 2,4-diamino-
35 5-cyanopyridine, mp 201-202°C.

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Analysis calculated for $C_6H_6N_4$:

Theory: C, 53.73; H, 4.51; N, 41.78.

Found: C, 53.69; H, 4.18; N, 41.40.

5

EXAMPLE 15

2,4-Diaminonicotinaldehyde

A suspension of 13.4 g of 2,4-diamino-5-cyanopyridine from Example 14, 2 g of Raney nickel catalyst, 40 mL of 97-100% formic acid, and 80 mL of water were shaken in a Parr apparatus under an atmosphere of nitrogen until the requisite amount of hydrogen was consumed. The solvents were removed under reduced pressure and the residue treated with 17 mL of concentrate HCl. The resulting pink solid was slurried in a small amount of water, filtered, washed with isopropyl alcohol, followed by diethylether, and dried. Crystallization from ethanol afforded 6.5 g of the title compound 2,4-diaminonicotinaldehyde.

Analysis calculated for $C_6H_8N_3ClO$:

Theory: C, 41.52; H, 4.65; N, 24.21.

Found: C, 41.47; H, 4.63; N, 24.05.

EXAMPLE 16

3-o-Tolyl-[1,6]naphthyridine-2,7-diamine

To a solution of 0.55 g of sodium dissolved in 50 mL of 2-ethoxyethanol was added 2.3 g of 2-methylphenylacetonitrile and 3.0 g of 2,4-diaminonicotinaldehyde from Example 15. The reaction mixture was heated under reflux for 6 hours. The insoluble salts were removed by filtration and washed with 2-ethoxyethanol. The filtrate was treated with charcoal, filtered, and evaporated to dryness. The residue was purified by chromatography over florisil, eluting with a gradient of 0-8% methanol in chloroform to afford 0.7 g of the title compound 3-o-tolyl-[1,6]naphthyridine-2,7-diamine, mp 200-201.5°C dec.

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Analysis calculated for $C_{15}H_{14}N_4$:

Theory: C, 72.03; H, 5.63; N, 22.38.

Found: C, 71.79; H, 5.45; N, 22.18.

5

EXAMPLE 17

3-(2-Chlorophenyl)-[1,6]naphthyridine-2,7-diamine

3-(2-Chlorophenyl)-[1,6]naphthyridine-2,7-diamine

was prepared as described above in Example 16

substituting 2-chlorophenylacetonitrile for

10 2-methylphenylacetonitrile, mp 175°C (MS).

EXAMPLE 18

3-(2,6-Dichlorophenyl)-[1,6]-naphthyridine-2,7-diamine

3-(2,6-Dichlorophenyl)-[1,6]-naphthyridine-

15 2,7-diamine was prepared as described above in

Example 16 substituting 2,6-dichlorophenylacetonitrile

for 2-methylphenylacetonitrile, mp 235-237°C dec.

Analysis calculated for $C_{14}H_{10}N_4Cl_2$:

Theory: C, 55.10; H, 3.30; N, 18.36; Cl, 23.24.

20 Found: C, 54.87; H, 3.21; N, 18.45; Cl, 23.04.

EXAMPLE 19

N²,N⁷-Dimethyl-6-phenyl-pyrido[2,3-d]pyrimidine-2,7-diamine

25 A mixture of 45 g of the disulfamate salt of
6-phenyl-pyrido[2,3-d]pyrimidine-2,7-diamine (U.S.
Patent Number 3,534,039) and 500 g of methylamine were
heated at 205-210°C in a bomb for 10 hours. The bomb
was washed with methanol and combined with the reaction
30 mixture. The mixture was heated to a boil, filtered,
and diluted with 200 mL of water. The filtrate was
removed in vacuo and the residue slurried in ice-water.
The insoluble material was filtered and washed with
cold water. The solid was dissolved in chloroform,
35 filtered to remove impurities, and washed several times
with water. The organic layer was dried (potassium

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carbonate) and evaporated. The product was crystallized from isopropyl alcohol to afford 15 g of the title compound N²,N⁷-dimethyl-6-phenyl-pyrido-[2,3-d]pyrimidine-2,7-diamine, mp 204-205°C.

5 Analysis calculated for C₁₅H₁₅N₅:

Theory: C, 67.90; H, 5.70; N, 26.90.

Found: C, 67.89; H, 5.62; N, 26.66.

EXAMPLE 20

10 7-Amino-6-(2,6-dichlorophenyl)-2-(3-diethylamino-propylamino)-pyrido[2,3-d]pyrimidine

A mixture of 2,7-diamino-6-(2,6-dichlorophenyl)-pyrido[2,3-d]pyrimidine (3.0 g) from Example 1, sulfamic acid (2 g) and 3-(diethylamino)propylamine
15 (30 mL) was heated to reflux with stirring for 18 hours. The reaction mixture was allowed to cool to room temperature and poured into ice-water (500 mL). The insoluble product was filtered, washed with water, slurried in warm diisopropyl ether, and filtered to
20 give a white solid. Crystallization from ethyl acetate afforded 1.5 g of 7-amino-6-(2,6-dichlorophenyl)-2-(3-diethylamino-propylamino)-pyrido[2,3-d]pyrimidine, mp 220-230°C.

25 EXAMPLE 21

1-tert-Butyl-3-[6-(2,6-dichlorophenyl)-2-(3-diethyl-amino-propylamino)-pyrido[2,3-d]pyrimidin-7-yl]-urea

To a solution of 7-amino-6-(2,6-dichlorophenyl)-2-(3-diethylamino-propylamino)-pyrido[2,3-d]pyrimidine
30 (0.48 g) from Example 20 in DMF (5 mL) was added 60% sodium hydride suspension (46 mg), and the mixture was stirred for 1 hour at room temperature. To the reaction mixture was added t-butyl isocyanate (0.113 g), and the mixture was stirred for 18 hours.
35 The reaction mixture was diluted with water and the insoluble material was collected by filtration. The

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solid was suspended in water (20 mL) and acidified with 1.0N HCl to form a solution. Activated charcoal was added to the solution, and the suspension filtered through celite, washing with water. The filtrate was made basic with 1.0N NaOH, and the insoluble product was collected by filtration and washed with water. A 180-mg sample of the product was further purified by reverse phase preparative HPLC on a C18 reverse phase column, eluting with a solvent gradient starting from 86% of 0.1% trifluoroacetic acid in water/14% acetonitrile to 14% of 0.1% trifluoroacetic acid in water/86% acetonitrile over a 22-minute time period to afford 165 mg of 1-tert-butyl-3-[6-(2,6-dichlorophenyl)-2-(3-diethylamino-propylamino)-pyrido[2,3-d]pyrimidin-7-yl]-urea, mp dec >80°C. Analysis calculated for $C_{25}H_{33}N_7O_1Cl_2 \cdot 0.22 CF_3CO_2H$:
C, 56.21; H, 6.16; N, 18.04.
Found: C, 56.13; H, 6.02; N, 18.14.

20

EXAMPLE 22

1-[2-Amino-6-(2,6-dichlorophenyl)-pyrido[2,3-d]-pyrimidin-7-yl]-3-ethylurea

2,7-Diamino-6-(2,6-dichlorophenyl)-pyrido[2,3-d]-pyrimidine was reacted with ethyl isocyanate according to the general procedure of Example 2. The crude product was purified by radial chromatography eluting with a gradient of 70% ethyl acetate/30% chloroform to 100% chloroform to give the title compound, 1-[2-amino-6-(2,6-dichlorophenyl)-pyrido[2,3-d]pyrimidin-7-yl]-3-ethylurea, mp 185-187°C. Analysis calculated for $C_{16}H_{14}N_6O_1Cl_2 \cdot 0.15 EtOAc$:
C, 51.07; H, 3.92; N, 21.52.
Found: C, 50.74; H, 3.75; N, 21.50.

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EXAMPLE 23

1-[2-Amino-6-(2,6-dichlorophenyl)-pyrido[2,3-d]-
pyrimidin-7-yl]-3-(3-morpholin-4-yl-propyl)-thiourea

2,7-Diamino-6-(2,6-dimethylphenyl)-pyrido[2,3-d]-
pyrimidine was reacted with 3-morpholinopropyl
isothiocyanate according to the general procedure of
Example 21. The crude product was purified by radial
chromatography eluting with a gradient of 2-8% methanol
in methylene chloride to give 1-[2-amino-6-(2,6-
dichlorophenyl)-pyrido[2,3-d]pyrimidin-7-yl]-3-
(3-morpholin-4-yl-propyl)-thiourea, mp 178-181°C dec;
Analysis calculated for C₂₁H₂₃N₇O₁Cl₂:

C, 51.22; H, 4.71; N, 19.91.

Found: C, 50.95; H, 4.63; N, 19.74.

EXAMPLE 24

2-[2-Amino-6-(2,6-dichlorophenyl)-pyrido[2,3-d]-
pyrimidin-7-yl]-amino-4,5-dihydro-oxazole

To a suspension of 2,7-diamino-6-(2,6-dichloro-
phenyl)-pyrido[2,3-d]pyrimidine (5.0 g) from Example 1
in DMF (50 mL) was added 0.65 g of NaH (60%) in
portions. The mixture was stirred for 1 hour at
ambient temperature, then 2-chloroethyl isocyanate
(1.72 g) was added, and the mixture was stirred for an
additional 18 hours at ambient temperature. The
reaction mixture was diluted with 100 mL of water and
filtered to provide an insoluble crude product. The
crude product was purified by flash chromatography
eluting with a gradient of 2-3% methanol in methylene
chloride to afford 1.0 g of a white solid. The solid
was further purified by recrystallization from
chloroform-ethyl acetate to give the title compound
2-[2-amino-6-(2,6-dichlorophenyl)-pyrido[2,3-d]-
pyrimidine-7-yl]amino-4,5-dihydro-oxazole. Further
analysis of the reaction mixture also showed the
presence of 1-[2-amino-6-(2,6-dichlorophenyl)-

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pyrido[2,3-d]pyrimidin-7-yl]-imidazolidin-2-one,
MS(FAB).

Analysis calculated for $C_{16}H_{13}N_6O_1Cl_2 \cdot 0.12 CHCl_3 \cdot 0.04$:

C, 51.22; H, 4.71; N, 19.91.

5 Found: C, 50.95; H, 4.63; N, 19.74.

EXAMPLE 25

1-Butyl-3-[7-(3-butyl-ureido)-6-(2,6-dichlorophenyl)-
pyrido[2,3-d]pyrimidin-2-yl]-urea

10 A mixture of 0.5 g 2,7-Diamino-6-(2,6-
dichlorophenyl)-pyrido[2,3-d]pyrimidine from Example 1
and 15 mL of n-butyl isocyanate is refluxed for
2 hours. The reaction mixture is allowed to cool to
room temperature and the insoluble material filtered.
15 The solid is recrystallized several times from ethanol
to give the title compound; mp 200-202°C.

Analysis calculated for $C_{23}H_{27}Cl_2N_7O_2 \cdot 0.35 H_2O$:

C, 54.09; H, 5.47; N, 19.20.

20 Found: C, 54.09; H, 5.27; N, 19.14.

EXAMPLE 26

1-[2-Amino-6-(2,6-dichlorophenyl)-pyrido[2,3-d]-
pyrimidin-7-yl]-3-propyl-urea

25 The title compound was prepared as described in
Example 2 by reacting 1.0 g of 2,7-diamino-6-(2,6-
dichlorophenyl)-pyrido[2,3-d]pyrimidine from Example 1
and 0.339 g of n-propyl isocyanate. The product was
purified by radial chromatography eluting with a
gradient of 10-100% ethyl acetate/Hexane. MS(CI).

30 Analysis calculated for $C_{17}H_{16}Cl_2N_6O_1 \cdot 0.43 H_2O$:

C, 51.17; H, 4.26; N, 21.06.

Found: C, 51.15; H, 3.90; N, 20.80.

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EXAMPLE 27

7-Amino-6-(2,6-dichlorophenyl)-2-(3-dimethylamino-propylamino)-pyrido[2,3-d]pyrimidine

5 The title compound was prepared as in Example 20 by reacting 3.0 g of 2,7-diamino-6-(2,6-dichlorophenyl)-pyrido[2,3-d]pyrimidine from Example 1 and 60 mL of 3-(dimethylamino)propylamine to give the title compound.

10

EXAMPLE 28

1-tert-Butyl-3-[6-(2,6-dichlorophenyl)-2-(3-dimethylamino-propylamino)-pyrido[2,3-d]pyrimidin-7-yl]-urea

15 Following the procedure of Example 21, 1.62 g of 7-amino-6-(2,6-dichlorophenyl)-2-(3-dimethylamino-propylamino)-pyrido[2,3-d]pyrimidine from Example 27 was reacted with 0.48 g of t-butyl isocyanate to give the title compound; mp gradually dec above 130°C.

Analysis calculated for $C_{23}H_{29}Cl_2N_7O_1 \cdot 1.45 H_2O$:

20 C, 53.48; H, 6.22; N, 18.98.

Found: C, 53.50; H, 5.84; N, 18.73.

EXAMPLE 29

7-Amino-6-(2,6-dichlorophenyl)-2-(3-dimethylamino-2,2-dimethyl-propylamino)-pyrido[2,3-d]pyrimidine

25 The title compound was prepared as described above in Example 20 by reacting 2.0 g of 2,7-diamino-6-(2,6-dichlorophenyl)-pyrido[2,3-d]pyrimidine from Example 1 and 15 mL of N,N,2,2-tetramethyl-1,3-propanediamine.

30

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EXAMPLE 30

1-tert-Butyl-3-[6-(2,6-dichlorophenyl)-2-(3-dimethylamino-2,2-dimethyl-propylamino)-pyrido[2,3-d]pyrimidin-7-yl]-urea

- 5 Following the procedure of Example 21, 1.0 g of 7-amino-6-(2,6-dichlorophenyl)-2-(3-dimethylamino-2,2-dimethyl-propylamino)-pyrido[2,3-d]pyrimidine from Example 29 was reacted with 0.26 g of t-butyl isocyanate to give the title compound; mp 161-170°C.
- 10 Analysis calculated for $C_{25}H_{33}Cl_2N_7O_1 \cdot 0.74 H_2O$:
C, 56.46; H, 6.54; N, 18.44.
Found: C, 56.47; H, 6.24; N, 18.41.

EXAMPLE 31

- 15 7-Amino-6-(2,6-dichlorophenyl)-2-(3-(2-picoline)-propylamino)-pyrido[2,3-d]pyrimidine

- 20 The title compound was prepared as described above in Example 20 starting from 2.0 g of 2,7-diamino-6-(2,6-dichlorophenyl)-pyrido[2,3-d]pyrimidine from Example 1 and 15 mL of 1-(3-aminopropyl)-2-picoline to give the title compound.

EXAMPLE 32

- 25 1-tert-Butyl-3-[6-(2,6-dichlorophenyl)-2-[3-(2-methyl-piperidin-1-yl)-propylamino]-pyrido[2,3-d]pyrimidin-7-yl]-urea

- 30 According to Example 21, 1.54 g of 7-amino-6-(2,6-dichlorophenyl)-2-(3-(2-picoline)-propylamino)-pyrido[2,3-d]pyrimidine from Example 31 was reacted with 0.377 g of t-butyl isocyanate to give the title compound.
- 35 Analysis calculated for $C_{27}H_{35}Cl_2N_7O_1$:
C, 59.56; H, 6.48; N, 18.01.
Found: C, 59.71; H, 6.53; N, 17.62.

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EXAMPLE 33

7-Amino-6-(2,6-dichlorophenyl)-2-(4-(4-methyl-piperazin-1-yl)-butylamino)-pyrido[2,3-d]pyrimidine

5 Following the procedure of Example 20, 2.0 g of 2,7-diamino-6-(2,6-dichlorophenyl)-pyrido[2,3-d]-pyrimidine from Example 1 was reacted with 15 mL of 1-(4-aminobutyl)-4-methyl-piperazine to give the title compound.

EXAMPLE 34

10 1-tert-Butyl-3-{6-(2,6-dichlorophenyl)-2-[4-(4-methyl-piperazin-1-yl)-butylamino]-pyrido[2,3-d]pyrimidin-7-yl}-urea

15 According to Example 21, 1.07 g of 7-amino-6-(2,6-dichlorophenyl)-2-(4-(4-methylpiperazine)-butylamino)-pyrido[2,3-d]pyrimidine from above in Example 33 was reacted with 0.253 g of t-butyl isocyanate to give the title compound.

ESMS m/z (relative intensity) 559 (M⁺, 100)

20 Analysis calculated for C₂₇H₃₆Cl₂N₈O₁·0.6 H₂O:

C, 56.86; H, 6.57; N, 19.65.

Found: C, 56.87; H, 6.31; N, 19.57.

EXAMPLE 35

25 6-(2,6-Dichlorophenyl)-N⁷-(5,6-dihydro-4H-[1,3]oxazin-2-yl)-N²-[3-(4-methyl-piperazin-1-yl)-propyl]-pyrido[2,3-d]pyrimidine-2,7-diamine

30 To a solution of 1.0 g of 6-(2,6-dichlorophenyl)-N²-[3-(4-methyl-piperazin-1-yl)-propyl[2,3-d]-pyrimidine-2,7-diamine from Example 36 in 10 mL of dimethylformamide was added sodium hydride (60% in oil, 0.094 g), and the mixture was stirred for 1 hour at ambient temperature. To the reaction mixture was added 0.268 g of 3-chloropropyl isocyanate, and the mixture
35 was stirred at ambient temperature for 18 hours. The reaction mixture was diluted with water and extracted

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twice with ethyl acetate. The combined organic layers were dried (MgSO_4), filtered, and evaporated. The crude product was purified twice by radial chromatography eluting with ethyl acetate/methanol/triethylamine (89:10:1 v/v/v) to give the title compound.

ESMS m/z (relative intensity) 529.4 (M^+ , 100)

EXAMPLE 36

10 N^2 -[3-(4-methyl-piperazin-1-yl)-propyl]-6-(2,6-dichlorophenyl)-pyrido[2,3-d]pyrimidine-2,7-diamine

A mixture of 2,7-diamino-6-(2,6-dichlorophenyl)-pyrido[2,3-d]pyrimidine (3.0 g) from Example 1, sulfamic acid (1.9 g), and 1-(3-aminopropyl)-4-methylpiperazine (15 mL) was heated to approximately 150°C for 24 hours. After cooling, the residue was dissolved in water. The aqueous solution was made alkaline with a solution of saturated sodium bicarbonate and extracted with dichloromethane several times. The dichloromethane layers were combined, dried over magnesium sulfate, and concentrated in vacuo. The residue was recrystallized from ethyl acetate to give 2.0 g of 6-(2,6-dichlorophenyl)- N^2 -[3-(4-methyl-piperazin-1-yl)-propyl]-pyrido[2,3-d]pyrimidine-2,7-diamine, CIMS (1% NH_3 in CH_4): 474 = M^+ + C_2H_5 , 446 = M^+ + H (Base); mp 208-211°C.

Analysis calculated for $\text{C}_{21}\text{H}_{25}\text{N}_7\text{Cl}_2 \cdot 0.25 \text{H}_2\text{O}$:

Theory: C, 55.94; H, 5.70; N, 21.75.

30 Found: C, 55.85; H, 5.55; N, 21.65.

EXAMPLE 37

35 1-Cyclohexyl-3-(6-(2,6-dichlorophenyl)-2-[3-(4-methyl-piperazin-1-yl)-propylamino]-pyrido[2,3-d]pyrimidin-7-yl)-urea

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To a solution of 6-(2,6-dichlorophenyl)-N²-[3-(4-methyl-piperazin-1-yl)-propyl]-pyrido[2,3-d]pyrimidine-2,7-diamine (1.0 g) from Example 36 in DMF (15 mL) was added one equivalent of 60% sodium hydride suspension (0.90 g). After stirring for approximately 1 hour at room temperature, one equivalent of cyclohexyl isocyanate (0.19 g) was added, and the reaction was monitored by thin layer chromatography. After approximately 24 hours, the solvent was removed in vacuo. The residue was dissolved in ethyl acetate, and this solution was washed several times, first with water and then a saturated solution of sodium chloride. The ethyl acetate layer was dried with magnesium sulfate and concentrated in vacuo. Chromatography of the residue on silica gel using ethyl acetate:ethanol:triethylamine (9:2:1 v/v/v) afforded 0.75 g of 1-cyclohexyl-3-{6-(2,6-dichlorophenyl)-2-[3-(4-methyl-piperazin-1-yl)-propylamino]pyrido[2,3-d]pyrimidin-7-yl}-urea, ESMS (20/80 MeOH/CH₃CN + 0.1% AcOH): M⁺ + H = 571; mp 101-106.5°C.

Analysis calculated for C₂₈H₃₆N₈Cl₂O·0.50 H₂O:
Theory: C, 57.93; H, 6.42; N, 19.30; Cl, 12.21;
H₂O, 1.55.
Found: C, 58.06; H, 6.32; N, 18.91; Cl, 12.11;
H₂O, 1.68.

EXAMPLE 38

1-(6-(2,6-Dichlorophenyl)-2-[3-(4-methyl-piperazin-1-yl-propylamino)]-pyrido[2,3-d]pyrimidin-7-yl)-3-isopropyl-urea

6-(2,6-Dichlorophenyl)-N²-[3-(4-methyl-piperazin-1-yl)-propyl]-pyrido[2,3-d]pyrimidine-2,7-diamine (1.09 g) from Example 36 was reacted with 0.19 g of isopropyl isocyanate for 8 hours according to the general procedure of Example 37 to give 0.291 g of 1-(6-(2,6-dichlorophenyl)-2-[3-(4-methyl-piperazin-1-yl)-

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propylamino]-pyrido[2,3-d]pyrimidin-7-yl}-3-isopropyl-
urea, MS (ES + 20/80 MeOH/CH₃CN + 0.1% AcOH): M⁺ + H =
531; mp 94-98°C.

Analysis calculated for C₂₅H₃₂N₈Cl₂O·0.75 H₂O/0.10
EtOAc:

Theory: C, 55.09; H, 6.24; N, 20.23; Cl, 12.80;
H₂O, 2.44.

Found: C, 55.14; H, 6.19; N, 20.03; Cl, 13.17;
H₂O, 2.14.

EXAMPLE 39

1-Benzyl-3-(6-(2,6-dichlorophenyl)-2-[3-(4-methyl-
piperazin-1-yl)-propylamino]-pyrido[2,3-d]pyrimidin-
7-yl)-urea

6-(2,6-Dichlorophenyl)-N²-[3-(4-methyl-piperazin-
1-yl)-propyl]-pyrido[2,3-d]pyrimidine-2,7-diamine
(1.08 g) from Example 36 was reacted with 0.298 g of
benzyl isocyanate according to the general procedure of
Example 37 to give 0.822 g of 1-benzyl-3-(6-(2,6-
dichlorophenyl)-2-[3-(4-methyl-piperazin-1-yl)-
propylamino]-pyrido[2,3-d]pyrimidin-7-yl)-urea, ESMS
(20/80 MeOH/CH₃CN + 0.1% AcOH): M⁺ + H = 579;
mp 144-148.5°C.

Analysis calculated for C₂₉H₃₂N₈Cl₂O·0.10 H₂O·0.10 Et₂O:

Theory: C, 59.98; H, 5.68; N, 19.03; Cl, 12.04;
H₂O, 0.31.

Found: C, 59.60; H, 5.63; N, 18.87; Cl, 12.25;
H₂O, 0.49.

EXAMPLE 40

1-Allyl-3-(6-(2,6-dichlorophenyl)-2-[3-(4-methyl-
piperazin-1-yl)-propylamino]-pyrido[2,3-d]pyrimidin-
7-yl)-urea

6-(2,6-Dichlorophenyl)-N²-[3-(4-methyl-piperazin-
1-yl)-propyl]-pyrido[2,3-d]pyrimidine-2,7-diamine
(1.0 g) from Example 36 was reacted with 0.186 g of

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allyl isocyanate according to the general procedure of Example 37. The product was purified by chromatography and crystallized from ethyl acetate to give 0.31 g of 1-allyl-3-{6-(2,6-dichlorophenyl)-2-[3-(4-methyl-

5 piperazin-1-yl)-propylamino]-pyrido[2,3-d]pyrimidin-7-yl}-urea, ESMS (20/80 MeOH/CH₃CN + 0.1% AcOH):

M⁺ + H = 529 (Base), 472, 446; mp 104-108°C.

Analysis calculated for C₂₅H₃₀N₈Cl₂O·1.00 H₂O:

Theory: C, 54.85; H, 5.89; N, 20.47; Cl, 12.95;

10 H₂O, 3.29.

Found: C, 55.08; H, 5.68; N, 20.33; Cl, 12.65;

H₂O, 3.60.

EXAMPLE 41

15 1-{6-(2,6-Dichlorophenyl)-2-[3-(4-methyl-piperazin-
1-yl)-propylamino]-pyrido[2,3-d]pyrimidin-7-yl}-3-
(4-methoxy-phenyl)-urea

6-(2,6-Dichlorophenyl)-N²-[3-(4-methyl-piperazin-1-yl)-propyl]-pyrido[2,3-d]pyrimidine-2,7-diamine

20 (1.0 g) from Example 36 was reacted with

4-methoxyphenyl isocyanate (0.334 g) according to the general procedure of Example 37 to give 1.16 g of

1-{6-(2,6-dichlorophenyl)-2-[3-(4-methyl-piperazin-1-yl)-propylamino]-pyrido[2,3-d]pyrimidin-7-yl}-3-(4-

25 methoxy-phenyl)-urea, ESMS (20/80 MeOH/CH₃CM + 0.1% AcOH): M⁺ + H = 595; mp 93.5-100.5°C.

Analysis calculated for C₂₉H₃₂N₈Cl₂O₂·0.40 H₂O·0.10

EtOAc:

Theory: C, 57.74; H, 5.54; N, 18.32; Cl, 11.59;

30 H₂O, 1.18.

Found: C, 58.04; H, 5.51; N, 18.15; Cl, 11.25;

H₂O, 1.38.

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EXAMPLE 42

1-(6-(2,6-Dichlorophenyl)-2-[3-(4-methyl-piperazin-1-yl)-propylamino]-pyrido[2,3-d]pyrimidin-7-yl)-3-(3-methoxy-phenyl)-urea

5 6-(2,6-Dichlorophenyl)-N²-[3-(4-methyl-piperazin-1-yl)-propyl]-pyrido[2,3-d]pyrimidine-2,7-diamine
(1.0 g) from Example 36 was reacted with 0.334 g of 3-methoxyphenyl isocyanate according to the general procedure of Example 37 to give 0.920 g of 1-(6-(2,6-dichlorophenyl)-2-[3-(4-methyl-piperazin-1-yl)-propylamino]-pyrido[2,3-d]pyrimidin-7-yl)-3-(3-methoxy-phenyl)-urea, ESMS (20/80 MeOH/CH₃CN + 0.1% AcOH):
10 M⁺ + H = 595; mp 87.5-92.5°C.

Analysis calculated for C₂₉H₃₂N₈Cl₂O₂·0.50 H₂O:
15 Theory: C, 57.62; H, 5.50; N, 18.54; Cl, 11.73;
 H₂O, 1.49.
 Found: C, 57.93; H, 5.62; N, 18.47; Cl, 11.66;
 H₂O, 1.10.

20

EXAMPLE 43

1-(6-(2,6-Dichlorophenyl)-2-[3-(4-methyl-piperazin-1-yl)-propylamino]-pyrido[2,3-d]pyrimidin-7-yl)-3-(2-methoxy-phenyl)-urea

25 6-(2,6-Dichlorophenyl)-N²-[3-(4-methyl-piperazin-1-yl)-propyl]-pyrido[2,3-d]pyrimidine-2,7-diamine
(1.0 g) from Example 36 was reacted with 0.334 of 2-methoxyphenyl isocyanate according to the general procedure of Example 37 to give 0.9232 g of 1-(6-(2,6-dichlorophenyl)-2-[3-(4-methyl-piperazin-1-yl)-propylamino]-pyrido[2,3-d]pyrimidin-7-yl)-3-(2-methoxy-phenyl)-urea, ESMS (20/80 MeOH/CH₃CN + 0.1% AcOH):
30 M⁺ + H = 595; mp 152.5-154°C.

Analysis calculated for C₂₉H₃₂N₈Cl₂O₂:
35 Theory: C, 58.49; H, 5.42; N, 18.82; Cl, 11.91.
 Found: C, 58.42; H, 5.56; N, 18.59; Cl, 11.82.

EXAMPLE 44

5 6-(2,6-Dichlorophenyl)-N²-[3-(4-methyl-piperazin-
1-yl)-propyl]-pyrido[2,3-d]pyrimidine-2,7-diamine
10 (1.0 g) from Example 36 was reacted with 0.44 g of
4-bromophenyl isocyanate according to the general
procedure of Example 37 to give 0.97 g of 1-(4-Bromo-
phenyl)-3-{6-(2,6-dichlorophenyl)-2-[3-(4-
methylpiperazin-1-yl)-propylamino]-pyrido[2,3-
d]pyrimidin-7-yl}-urea, ESMS (20/80 MeOH/CH₃CN + 0.1%
AcOH + DMSO): M⁺ + H = 645; mp 171-175°C.
Analysis calculated for C₂₈H₂₉N₈Cl₂OBr:
15 Theory: C, 52.19; H, 4.54; N, 17.39; Cl, 11.00;
 Br, 12.40.
 Found: C, 51.93; H, 4.71; N, 17.14; Cl, 10.81;
 Br, 12.18.

1-(4-Chloro-phenyl)-3-{6-(2,6-dichlorophenyl)-2-[3-(4-methyl-piperazin-1-yl)-propylamino]-pyrido[2,3-d]-pyrimidin-7-yl}-urea

6-(2,6-Dichlorophenyl)-N²-[3-(4-methyl-piperazin-
1-yl)-propyl]-pyrido[2,3-d]pyrimidine-2,7-diamine
(1.0 g) from Example 36 was reacted with 0.344 g of 4-
chlorophenyl isocyanate according to the general
procedure of Example 37 to give 0.8424 g of 1-(4-
Chloro-phenyl)-3-{6-(2,6-dichlorophenyl)-2-[3-(4-
methyl-piperazin-1-yl)-propylamino]-pyrido[2,3-
d]pyrimidin-7-yl}-urea, ESMS (20/80 MeOH/CH₃CN + 0.1%
AcOH + DMSO): M⁺ + H = 601; mp 175.5-181°C.
Analysis calculated for C₂₈H₂₉N₈Cl₃O:
Theory: C, 56.06; H, 4.87; N, 18.68; Cl, 17.73.
Found: C, 56.11; H, 5.14; N, 18.47; Cl, 17.67.

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EXAMPLE 46

1-(6-(2,6-Dichlorophenyl)-2-[3-(4-methyl-piperazin-1-yl)-propylamino]-pyrido[2,3-d]pyrimidin-7-yl)-3-p-tolyl-urea

5 6-(2,6-Dichlorophenyl)-N²-[3-(4-methyl-piperazin-1-yl)-propyl]-pyrido[2,3-d]pyrimidine-2,7-diamine from Example 36 was reacted with 0.29 g of 4-tolyl isocyanate according to the general procedure of Example 37 to give 0.9492 g of the title compound.

10 ESMS (20/80 MeOH/CH₃CN + 0.1% AcOH): M⁺ + H = 579; Analysis calculated for C₂₉H₃₂N₈Cl₂O·0.30 H₂O + 0.20 EtOAc:

Theory: C, 59.40; H, 5.72; N, 18.60; Cl, 11.77;
 H₂O, 0.90.

15 Found: C, 59.69; H, 5.61; N, 18.41; Cl, 11.50;
 H₂O, 1.31.

EXAMPLE 47

20 1-(6-(2,6-Dichlorophenyl)-2-[3-(4-methyl-piperazin-1-yl)-propylamino]-pyrido[2,3-d]pyrimidin-7-yl)-3-octyl-urea

 6-(2,6-Dichlorophenyl)-N²-[3-(4-methyl-piperazin-1-yl)-propyl]-pyrido[2,3-d]pyrimidine-2,7-diamine (1.0 g) from Example 36 was reacted with 0.348 g of octyl isocyanate according to the general procedure of Example 21. Chromatography, eluting first with ethyl acetate:methyl alcohol:triethylamine (90:10:1) then switching to ethyl acetate:ethanol:triethylamine (9:2:1) gave 1.011 g of the title compound 1-(6-(2,6-dichlorophenyl)-2-[3-(4-methyl-piperazin-1-yl)-propylamino]-pyrido[2,3-d]-pyrimidin-7-yl)-3-octyl-urea, ESMS (20/80 MeOH/CH₃CN + 0.1% AcOH): M⁺ + H = 601; mp 54.5-57.5°C.

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Analysis calculated for $C_{30}H_{42}N_8Cl_2O \cdot 0.75 H_2O$:

Theory: C, 58.58; H, 7.13; N, 18.22; Cl, 11.53;
H₂O, 2.20.

Found: C, 58.51; H, 7.13; N, 18.13; Cl, 11.55;
H₂O, 2.32.

5

EXAMPLE 48

10 1-{6-(2,6-Dichlorophenyl)-2-[3-(4-methyl-piperazin-1-yl)-propylamino]-pyrido[2,3-d]pyrimidin-7-yl}-3-(4-trifluoromethyl-phenyl)-urea
6-(2,6-Dichlorophenyl)-N²-[3-(4-methyl-piperazin-1-yl)-propyl]-pyrido[2,3-d]pyrimidine-2,7-diamine from Example 36 was reacted with trifluoro-p-tolyl isocyanate according to the general procedure of Example 37. Chromatography, eluting first with ethyl acetate:methyl alcohol:triethylamine (90:10:1) then switching to ethyl acetate:ethanol:triethylamine (9:2:1) gave 0.8650 g of the title compound 1-{6-(2,6-dichlorophenyl)-2-[3-(4-methyl-piperazin-1-yl)-propylamino]-pyrido[2,3-d]pyrimidin-7-yl}-3-(4-trifluoromethyl-phenyl)-urea, ESMS (20/80 MeOH/CH₃CN + 0.1% AcOH): M⁺ + H = 633; mp 145.5-151°C.
20 Analysis calculated for $C_{29}H_{29}N_8Cl_2F_3O \cdot 0.50 H_2O$:
Theory: C, 54.21; H, 4.71; N, 17.44; Cl, 11.04;
25 F, 8.87; H₂O, 1.40.
Found: C, 54.39; H, 4.59; N, 17.28; Cl, 11.10;
F, 9.17; H₂O, 1.61.

EXAMPLE 49

30 1-{6-(2,6-Dichlorophenyl)-2-[3-(4-methyl-piperazin-1-yl)-propylamino]-pyrido[2,3-d]pyrimidin-7-yl}-3-ethyl-urea
6-(2,6-Dichlorophenyl)-N²-[3-(4-methyl-piperazin-1-yl)-propyl]-pyrido[2,3-d]pyrimidine-2,7-diamine (1.0 g) from Example 36 was reacted with 0.159 g of ethyl isocyanate according to the general procedure of

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Example 37 to give 0.86 g of 1-{6-(2,6-dichlorophenyl)-
2-[3-(4-methyl-piperazin-1-yl)-propylamino]-pyrido-
[2,3-d]pyrimidin-7-yl}-3-ethyl-urea, MS (ES + 20/80
MeOH/CH₃CN + 0.1% AcOH): M⁺ + H = 517; mp 82-90°C.

5 Analysis calculated for C₂₄H₃₀N₈Cl₂O·1.00 H₂O:

Theory: C, 53.83; H, 6.02; N, 20.93; Cl, 13.24;
H₂O, 3.26.

Found: C, 53.94; H, 6.07; N, 20.53; Cl, 13.14;
H₂O, 3.28.

10

EXAMPLE 50

1-{6-(2,6-Dichlorophenyl)-2-[3-(4-methyl-piperazin-
1-yl)-propylamino]-pyrido[2,3-d]pyrimidin-7-yl}-
3-naphthalen-1-yl-urea

15

6-(2,6-Dichlorophenyl)-N²-[3-(4-methyl-piperazin-
1-yl)-propyl]-pyrido[2,3-d]pyrimidine-2,7-diamine
(1.0 g) from Example 36 was reacted with 0.378 g of
1-naphthyl isocyanate according to the general
procedure of Example 37. Chromatography, eluting first
20 with ethyl acetate:methyl alcohol:triethylamine
(90:10:1) then switching to ethyl

acetate:ethanol:triethylamine (9:2:1) gave 0.97 g of
the title compound 1-{6-(2,6-dichlorophenyl)-2-[3-(4-
methyl-piperazin-1-yl)-propylamino]-pyrido[2,3-d]-
25 pyrimidin-7-yl}-3-naphthalen-1-yl-urea, ESMS (20/80
MeOH/CH₃CN + 0.1% AcOH): M⁺ + H = 615 (Base), 446;
mp 186.5-189°C.

Analysis calculated for C₃₂H₃₂N₈Cl₂O·0.10 H₂O:

Theory: C, 62.26; H, 5.26; N, 18.15; Cl, 11.49;
H₂O, 0.29.

30

Found: C, 62.25; H, 5.26; N, 18.38; Cl, 11.39;
H₂O, 0.51.

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EXAMPLE 51

1-(6-(2,6-Dichlorophenyl)-2-[3-(4-methyl-piperazin-1-yl)-propylamino]-pyrido[2,3-d]pyrimidin-7-yl)-3-phenyl-urea

- 5 6-(2,6-Dichlorophenyl)-N²-[3-(4-methyl-piperazin-1-yl)-propyl]-pyrido[2,3-d]pyrimidine-2,7-diamine (13.0 g) from Example 36 in DMF (160 mL) was reacted with 60% sodium hydride suspension (1.16 g) and phenyl isocyanate (3.47 g) according to the general procedure of Example 37. Recrystallization of the chromatographed product from ethyl acetate gave 10.78 g of the title compound 1-(6-(2,6-dichlorophenyl)-2-[3-(4-methyl-piperazin-1-yl)-propylamino]-pyrido[2,3-d]pyrimidin-7-yl)-3-phenyl-urea, ESMS (20/80 MeOH/CH₃CN + 0.1% AcOH): M⁺ + H = 565; Analysis calculated for C₂₈H₃₀N₈Cl₂O·0.30 H₂O·0.20 EtOAc:
- 10 Theory: C, 58.78; H, 5.51; N, 19.04; Cl, 12.05; H₂O, 0.92.
- 15 Found: C, 58.72; H, 5.55; N, 18.84; Cl, 11.98; H₂O, 1.01.
- 20

EXAMPLE 52

1-tert-Butyl-3-(6-(2,6-dichlorophenyl)-2-[3-(4-methyl-piperazin-1-yl)-propylamino]-pyrido[2,3-d]pyrimidin-7-yl)-urea

- 25 6-(2,6-Dichlorophenyl)-N²-[3-(4-methyl-piperazin-1-yl)-propyl]-pyrido[2,3-d]pyrimidine-2,7-diamine (1.0 g) from Example 36 was reacted with 0.22 g of tert-butyl isocyanate for 1.5 hours according to the general procedure of Example 21 to give 0.85 g of the title compound 1-tert-Butyl-3-(6-(2,6-dichlorophenyl)-2-[3-(4-methyl-piperazin-1-yl)-propylamino]-pyrido[2,3-d]pyrimidin-7-yl)-urea, CIMS (1% NH₃ in CH₄): 545 = M⁺ + H, 544 = M⁺, 446, 84 (Base); mp dec. 97.5°C melts 106-109°C.
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- 35

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Analysis calculated for $C_{26}H_{34}N_8Cl_2O$:

Theory: C, 57.25; H, 6.28; N, 20.25.

Found: C, 56.91; H, 6.31; N, 20.30.

5

EXAMPLE 53

6-(2,6-Dichlorophenyl)-N²-(4-diethylamino-butyl)-
pyrido[2,3-d]pyrimidine-2,7-diamine

10 A mixture of 2,7-diamino-6-(2,6-dichlorophenyl)-
pyrido[2,3-d]pyrimidine (40 g) from Example 1, sulfamic
acid (25.4 g) and diethylaminobutylamine (205 mL) was
heated to approximately 150°C for 28 hours. The
reaction temperature was lowered to 50°C, and excess
diethylaminobutylamine was removed in vacuo. After
cooling to 25°C, the residue was suspended in water.
15 The aqueous solution was made alkaline with a solution
of saturated sodium bicarbonate and extracted with
dichloromethane several times. The dichloromethane
layers were combined, washed several times, first with
a saturated solution of sodium bicarbonate then a
20 saturated solution of sodium chloride, dried over
magnesium sulfate and concentrated in vacuo. The
residue was washed repeatedly with diethyl ether and
then crystallized from ethyl acetate. The
recrystallized product was further purified by column
25 chromatography, eluting first with ethyl acetate:methyl
alcohol:triethylamine (85:14:1) followed by ethyl
acetate:ethyl alcohol:triethylamine (9:2:1) to afford
36.2 g of the title compound 6-(2,6-dichlorophenyl)-N²-
(4-diethylamino-butyl)-pyrido[2,3-d]pyrimidine-2,7-
30 diamine, CIMS (1% N₃ in CH₄): 461 = M⁺ + C₂H₅, 433 =
M⁺ + H (Base), 417, 403, 360.

Analysis calculated for $C_{21}H_{26}N_6Cl_2$:

Theory: C, 58.20; H, 6.05; N, 19.39; Cl, 16.36.

Found: C, 58.11; H, 6.21; N, 19.09; Cl, 16.55.

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EXAMPLE 54

1-[6-(2,6-Dichlorophenyl)-2-(4-diethylamino-butylamino)-pyrido[2,3-d]pyrimidin-7-yl]-3-phenyl-urea

To a solution of 6-(2,6-dichlorophenyl)-N²-(4-diethylamino-butyl)-pyrido[2,3-d]pyrimidine-2,7-diamine (1.0 g) from Example 53 in DMF (15 mL) was added one equivalent of 60% sodium hydride suspension (0.93 g). After stirring for approximately 1 hour at room temperature, one equivalent of phenyl isocyanate (0.275 g) was added, and the reaction was monitored by thin layer chromatography. After approximately 24 hours, the solvent was removed in vacuo. The residue was dissolved in ethyl acetate, and this solution was washed several times, first with water and then a saturated solution of sodium chloride. The ethyl acetate layer was dried with magnesium sulfate and concentrated in vacuo. Chromatography of the residue over silica gel using ethyl acetate:methanol:triethylamine (90:10:1) followed by ethyl acetate:ethanol:triethylamine (9:2:1) gave 0.8461 g of the title compound 1-[6-(2,6-dichlorophenyl)-2-(4-diethylamino-butylamino)-pyrido[2,3-d]pyrimidin-7-yl]-3-phenyl-urea, ESMS (20/80 MeOH/CH₃CN + 0.1% AcOH): M⁺ + H = 552 (Base), 433; mp 81-87.5°C.

Analysis calculated for C₂₈H₃₁N₇Cl₂O·0.25 H₂O:
Theory: C, 60.38; H, 5.70; N, 17.60; Cl, 12.73; H₂O, 0.81.
Found: C, 60.24; H, 5.61; N, 17.42; Cl, 12.61; H₂O, 0.54.

30

EXAMPLE 55

1-[6-(2,6-Dichlorophenyl)-2-(4-diethylamino-butylamino)-pyrido[2,3-d]pyrimidin-7-yl]-3-ethyl-urea

6-(2,6-Dichlorophenyl)-N²-(4-diethylamino-butyl)-pyrido[2,3-d]pyrimidine-2,7-diamine (5.0 g) from Example 53 in DMF (75 mL) was reacted with 60% sodium

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hydride suspension (0.461 g) and ethyl isocyanate (0.820 g) according to the general procedure of Example 54. Chromatography with ethyl acetate:ethanol:triethylamine (9:2:1) gave 4.26 g of the title compound
5 1-[6-(2,6-dichlorophenyl)-2-(4-diethylamino-butyl-amino)-pyrido[2,3-d]pyrimidin-7-yl]-3-ethyl-urea, ESMS (20/80 MeOH/CH₃CN + 0.1% AcOH): M⁺ + H = 504 (Base), 433.

10

EXAMPLE 56

1-[6-(2,6-Dichlorophenyl)-2-(4-diethylamino-butylamino)-pyrido[2,3-d]pyrimidin-7-yl]-3-ethyl-urea, hydrochloride salt

To a solution of 1-[6-(2,6-dichlorophenyl)-2-(4-diethylamino-butylamino)-pyrido[2,3-d]pyrimidin-7-yl]-3-ethyl-urea (3.253 g) from Example 55 in water (250 mL) was added one equivalent of 1N hydrochloric acid (6.44 mL). The solution was stirred at room temperature until the solid was dissolved, filtered,
15 and frozen. Lyophilization gave 3.63 g the hydrochloric acid salt of 1-[6-(2,6-dichlorophenyl)-2-(4-diethylamino-butylamino)-pyrido[2,3-d]pyrimidin-7-yl]-3-ethyl-urea, ESMS (20/80 MeOH/CH₃CN + 1% AcOH): M⁺ + H = 504; mp dec >50°C.

25 Analysis calculated for C₂₄H₃₁N₇Cl₂O·1.10 HCl·2.20 H₂O:
Theory: C, 49.34; H, 6.30; N, 16.78; Cl_{Total}, 18.81;
Cl_{Ionic}, 6.67; H₂O, 6.78.
Found: C, 49.61; H, 6.21; N, 16.75; Cl_{Total}, 18.70;
Cl_{Ionic}, 6.68; H₂O, 6.88.

30

EXAMPLE 57

1-Cyclohexyl-3-[6-(2,6-dichlorophenyl)-2-(4-diethyl-amino-butylamino)-pyrido[2,3-d]pyrimidin-7-yl]-urea

35 6-(2,6-Dichlorophenyl)-N²-(4-diethylamino-butyl)-pyrido[2,3-d]pyrimidine-2,7-diamine (1.0 g) from Example 53 in DMF (15 mL) was reacted with 60% sodium

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hydride suspension (0.092 g) and cyclohexyl isocyanate (0.289 g) according to the general procedure of Example 54 to give 0.927 g of the title compound, ESMS (20/80 MeOH/CH₃CN + 0.1% AcOH): M⁺ + H = 558, 433.

5 Analysis calculated for C₂₈H₃₇N₇Cl₂O·0.10 H₂O:

Theory: C, 60.02; H, 6.69; N, 17.50; Cl, 12.65;
H₂O, 0.32.

Found: C, 59.75; H, 6.69; N, 17.41; Cl, 12.71;
H₂O, 0.40.

10

EXAMPLE 58

6-(2,6-Dichlorophenyl)-N²-(3-morpholin-4-yl-propyl)-pyrido[2,3-d]pyrimidine-2,7-diamine

15 A mixture of 2,7-diamino-6-(2,6-dichlorophenyl)-pyrido[2,3-d]pyrimidine (4.00 g) from Example 1, sulfamic acid (2.53 g) and aminopropylmorpholine (30 mL) was reacted as in Example 53. In this instance, the crude residue was washed with hot ethyl acetate followed by diethyl ether to afford 3.95 g of
20 the title compound 6-(2,6-dichlorophenyl)-N²-(3-morpholin-4-yl-propyl)-pyrido[2,3-d]pyrimidine-2,7-diamine, CIMS (1% NH₃ in CH₄): 461 = M⁺ + C₂H₅, 433 = M⁺ + H (Base), 346, 332; mp 224-230.5°C.

25 Analysis calculated for C₂₀H₂₂N₆Cl₂O:

Theory: C, 55.43; H, 5.12; N, 19.39.

Found: C, 55.12; H, 5.12; N, 19.14.

EXAMPLE 59

30 1-tert-Butyl-3-[6-(2,6-dichlorophenyl)-2-(3-morpholin-4-yl-propylamino)-pyrido[2,3-d]pyrimidin-7-yl]-urea

To a solution of 6-(2,6-dichlorophenyl)-N²-(3-morpholin-4-yl-propyl)-pyrido[2,3-d]pyrimidine-2,7-diamine (1.0 g) from Example 58 in DMF (15 mL) was added one equivalent of 60% sodium hydride suspension
35 (0.92 g). After stirring for approximately 1 hour at room temperature, one equivalent of tert-butyl

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isocyanate (0.230 g) was added, and the reaction was monitored by thin layer chromatography. After approximately 4 hours, the solvent was removed in vacuo. The residue was partitioned between ethyl acetate and water. The aqueous layer was washed several times with ethyl acetate. The ethyl acetate layers were combined, dried with magnesium sulfate, and concentrated in vacuo. Chromatography of the residue on silica gel using ethyl acetate followed by ethyl acetate:ethanol:triethylamine (18:2:1) gave 0.98 g of the title compound 1-tert-butyl-3-[6-(2,6-dichlorophenyl)-2-(3-morpholin-4-yl-propylamino)-pyrido[2,3-d]pyrimidin-7-yl]-urea, CIMS (1% NH₃ in CH₄): 532 = M⁺ + H, 531 = M⁺, 433, 84 (Base); mp 236-240°C.

Analysis calculated for C₂₅H₃₁N₇Cl₂O₂·0.25 EtOAc:

Theory: C, 56.32; H, 6.00; N, 17.68.

Found: C, 56.48; H, 6.06; N, 17.63.

EXAMPLE 60

6-(2,6-Dibromo-phenyl)-pyrido[2,3-d]pyrimidine-2,7-diamine

To a solution of 0.23 g 60% sodium hydride suspension in 11.0 mL of 2-ethoxyethanol was added 4.18 g of 2,6-dibromophenylacetonitrile and 2.00 g of 2,4-diaminopyrimidine-5-carboxaldehyde. The reaction was refluxed for 4 hours, cooled, and poured into ice water. The residue was washed well with acetonitrile then diethyl ether to give 3.62 g of 6-(2,6-dibromophenyl)-pyrido[2,3-d]pyrimidine-2,7-diamine, CIMS (1% NH₃ in CH₄): 422 = M⁺ + C₂H₅, 396 (Base), 394 = M⁺ + H, 393 = M⁺; mp 284-289°C.

Analysis calculated for C₁₃H₉N₅Br₂:

Theory: C, 39.52; H, 2.30; N, 17.73.

Found: C, 39.20; H, 2.27; N, 17.77.

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EXAMPLE 61

6-(2,6-Dibromo-phenyl)-N²-[3-diethylamino-propyl]-pyrido[2,3-d]pyrimidine-2,7-diamine

A mixture of 6-(2,6-dibromo-phenyl)-pyrido[2,3-d]pyrimidine-2,7-diamine (1.0 g) from Example 60, sulfamic acid (0.49 g), and diethylaminopropylamine (8.0 mL) was reacted for 5 hours and worked up as in Example 53 to afford 0.79 g of the title compound 6-(2,6-dibromo-phenyl)-N²-[3-diethylamino-propyl]-pyrido[2,3-d]pyrimidine-2,7-diamine, CIMS (1% NH₃ in CH₄): 507 = M⁺ + H, 506 = M⁺, 112 (Base); mp 226-230°C.

Analysis calculated for C₂₀H₂₄N₆Br₂:

Theory: C, 47.26; H, 4.76; N, 16.53.

Found: C, 47.61; H, 4.69; N, 16.40.

EXAMPLE 62

1-tert-Butyl-3-[6-(2,6-dibromo-phenyl)-2-(3-diethylamino-propylamino)-pyrido[2,3-d]pyrimidin-7-yl]-urea

6-(2,6-Dibromo-phenyl)-N²-[3-diethylamino-propyl]-pyrido[2,3-d]pyrimidine-2,7-diamine (0.34 g) from Example 61 was reacted with 0.066 g of tert-butyl isocyanate according to the general procedure of Example 54. The crude residue was purified by thin layer chromatography with ethyl acetate:ethanol:triethylamine (9:2:1) followed by preparative HPLC chromatography using a Vydac 218 TP 1022 reverse phase column with a gradient elution of 0.1% trifluoroacetic acid/water and 0.1% trifluoroacetic acid/acetonitrile to give 0.214 g of the title compound, ESMS (20/80

MEOH/CH₃CN + 0.1% AcOH): 606 = M⁺ + H; mp dec. >45°C.

Analysis calculated for C₂₅H₃₃N₇Br₂O·2.50 TFA·H₂O:

Theory: C, 39.58; H, 4.15; N, 10.77.

Found: C, 39.54; H, 3.82; N, 10.49.

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EXAMPLE 63

6-(2,6-Difluoro-phenyl)-pyrido[2,3-d]pyrimidine-2,7-diamine

5 6-(2,6-Difluoro-phenyl)-pyrido[2,3-d]pyrimidine-2,7-diamine was prepared as described above in Example 60 using 4.65 g of 2,6-difluorophenylacetonitrile, CIMS ($1\% \text{ NH}_3$ in CH_4): $414 = \text{M}^+ + \text{C}_3\text{H}_5$, $302 = \text{M}^+ + \text{C}_2\text{H}_5$, $274 = \text{M}^+ + \text{H}$ (Base), $273 = \text{M}^+$, $254 = \text{M}^+ - \text{F}$; mp $>300^\circ\text{C}$.

10 Analysis calculated for $\text{C}_{13}\text{H}_9\text{N}_5\text{F}_2$:
Theory: C, 57.14; H, 3.32; N, 25.63.
Found: C, 57.30; H, 3.52; N, 25.62.

EXAMPLE 64

15 6-(2,6-Dimethoxy-phenyl)-pyrido[2,3-d]pyrimidine-2,7-diamine

6-(2,6-Dimethoxy-phenyl)-pyrido[2,3-d]pyrimidine-2,7-diamine was prepared as described above in Example 60 substituting 2,6-dimethoxybenzylacetonitrile for 2,6-dibromophenylacetonitrile, reacting for 3 hours and crystallizing the product from ethyl alcohol, CIMS ($1\% \text{ NH}_3$ in CH_4): $326 = \text{M}^+ + \text{C}_2\text{H}_5$, $298 = \text{M}^+ + \text{H}$ (Base), $297 = \text{M}^+$, $266 = \text{M}^+ - \text{OMe}$; mp $>300^\circ\text{C}$.

20 Analysis calculated for $\text{C}_{15}\text{H}_{15}\text{N}_5\text{O}_2 \cdot 0.50 \text{ H}_2\text{O}$:
25 Theory: C, 58.82; H, 5.26; N, 22.86.
Found: C, 58.81; H, 5.04; N, 22.54.

EXAMPLE 65

30 6-(2,6-Dichlorophenyl)-N²-(2-diethylamino-ethyl)-pyrido[2,3-d]pyrimidine-2,7-diamine

A mixture of 2,7-diamino-6-(2,6-dichlorophenyl)-pyrido[2,3-d]pyrimidine (4.0 g) from Example 1, sulfamic acid (2.53 g), and diethylaminoethylamine (40 mL) was heated to approximately 150°C for 20 hours.
35 The excess diethylaminoethylamine was removed in vacuo. The resulting oil was dissolved in diethyl ether,

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- diluted with hexane, and then filtered. The resulting solid was dissolved in dichloromethane which was washed several times with water, dried with magnesium sulfate, and concentrated in vacuo. The residue was
- 5 crystallized from ethyl acetate to give the title compound 6-(2,6-dichlorophenyl)-N²-(2-diethylamino-ethyl)-pyrido[2,3-d]pyrimidine-2,7-diamine, CIMS (1% NH₃ in CH₄): 433 = M⁺ + C₂H₅, 405 = M⁺ + H, 389 = M⁺ - Et, 360; mp 216-219.5°C.
- 10 Analysis calculated for C₁₉H₂₂N₆Cl₂:
Theory: C, 56.30; H, 5.47; N, 20.73.
Found: C, 56.31; H, 5.39; N, 20.46.

EXAMPLE 66

- 15 1-tert-Butyl-3-[6-(2,6-dichlorophenyl)-2-(2-diethyl-amino-ethylamino)-pyrido[2,3-d]pyrimidin-7-yl]-urea
6-(2,6-Dichlorophenyl)-N²-(2-diethylamino-ethyl)-pyrido[2,3-d]pyrimidine-2,7-diamine (1.0 g) from Example 65 in DMF (10 mL) was reacted with 60% sodium
- 20 hydride suspension (0.099 g) and tert-butyl isocyanate (0.244 g) for 1 hour according to the general procedure of Example 54. Chromatography with ethyl acetate: ethanol:triethylamine (18:2:1) gave 0.76 g of the title
- 25 compound 1-tert-butyl-3-[6-(2,6-dichlorophenyl)-2-(2-diethylamino-ethylamino)-pyrido[2,3-d]pyrimidin-7-yl]-urea, CIMS (1% NH₃ in CH₄): 504 = M⁺ + H, 84 (Base); mp 94.5-96.5°C.
- Analysis calculated for C₂₄H₃₁N₇Cl₂O:
Theory: C, 57.14; H, 6.19; N, 19.44.
- 30 Found: C, 56.94; H, 6.18; N, 19.22.

EXAMPLE 67

- 1-[6-(2,6-Dichlorophenyl)-2-(2-diethylamino-ethyl-amino)-pyrido[2,3-d]pyrimidin-7-yl]-3-ethyl-urea
- 35 6-(2,6-Dichlorophenyl)-N²-(2-diethylamino-ethyl)-pyrido[2,3-d]pyrimidine-2,7-diamine (1.0 g) from

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Example 65 in DMF (10 mL) was reacted with 60% sodium hydride suspension (0.099 g) and ethyl isocyanate (0.175 g) according to the general procedure of Example 54 to give 0.86 g of the title compound
5 1-[6-(2,6-dichlorophenyl)-2-(2-diethylamino-ethylamino)-pyrido[2,3-d]pyrimidin-7-yl]-3-ethyl-urea, CIMS (1% NH₃ in CH₄): 476 = M⁺ + H, 86 (Base); mp 86.5-89.5°C.

Analysis calculated for C₂₂H₂₃N₇Cl₂O:

10 Theory: C, 55.47; H, 5.71; N, 20.58.

Found: C, 55.18; H, 5.74; N, 20.20.

EXAMPLE 68

15 6-(2,6-Dichlorophenyl)-N²-(3-dimethylamino-propyl)-N²-methyl-pyrido[2,3-d]pyrimidine-2,7-diamine

A mixture of 2,7-diamino-6-(2,6-dichlorophenyl)-pyrido[2,3-d]pyrimidine (4.0 g) from Example 1, sulfamic acid (2.53 g) and N,N,N'-trimethyl-1,3-propanediamine (20 mL) was heated in a bomb first at
20 165°C for 16 hours then at 225°C for 16 hours. After cooling, the reaction mixture was concentrated in vacuo. The residue was partitioned between dilute sodium bicarbonate and dichloromethane. The aqueous solution was extracted with dichloromethane several
25 times. The dichloromethane layers were combined, filtered, and concentrated in vacuo. The residue was chromatographed with ethyl acetate:ethanol: triethylamine (9:3:1) to give the title compound
30 6-(2,6-dichlorophenyl)-N²-(3-dimethylamino-propyl)-N²-methyl-pyrido[2,3-d]pyrimidine-2,7-diamine.

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EXAMPLE 69

1-tert-Butyl-3-(6-(2,6-dichlorophenyl)-2-[(3-dimethyl-
amino-propyl)-methyl-amino]-pyrido[2,3-d]pyrimidin-
7-yl)-urea

5 6-(2,6-Dichlorophenyl)-N²-(3-dimethylamino-
propyl)-N²-methyl-pyrido[2,3-d]pyrimidine-2,7-diamine
(0.38 g) from Example 68 in DMF (7.0 mL) was reacted
with 60% sodium hydride suspension (0.022 g) and tert-
butyl isocyanate (0.093 g) according to the general
10 procedure of Example 54 to give 0.25 g of the title
compound 1-tert-butyl-3-(6-(2,6-dichlorophenyl)-2-[(3-
dimethylamino-propyl)-methyl-amino]-pyrido[2,3-d]-
pyrimidin-7-yl)-urea, CIMS (1% NH₃ in CH₄):
504 = M⁺ + H, 84 (Base); mp dec 76°C then melts
15 87.5-91°C.

Analysis calculated for $C_{24}H_{31}N_7Cl_2O \cdot 0.25 H_2O$:

Theory: C, 56.64; H, 6.24; N, 19.26.

Found: C, 56.55; H, 6.07; N, 18.94.

20

EXAMPLE 70

2-({3-[7-Amino-6-(2,6-dichlorophenyl)-pyrido[2,3-d]-
pyrimidin-2-ylamino]-propyl}-ethyl-amino)-ethanol

A mixture of 2,7-diamino-6-(2,6-dichlorophenyl)-pyrido[2,3-d]pyrimidine (3.0 g) from Example 1, sulfamic acid (1.9 g) and N¹-ethyl-N¹-(2-hydroxyethyl)-propylenediamine (10.0 g) (J. Med. Chem., 11(3):583-591, (1968)) was reacted for 18 hours according to the general procedure of Example 36. In this instance, the residue was chromatographed using ethyl acetate: ethanol:triethylamine (9:3:1) to give 2.71 g of the title compound 2-((3-[7-amino-6-(2,6-dichlorophenyl)-pyrido[2,3-d]pyrimidin-2-ylamino]-propyl)-ethyl-amino)-ethanol, CIMS (1% NH₃ in CH₄): 463 = M⁺ + C₂H₅, 435 = M⁺ + H, 346 (Base); mp 201-204°C.

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Analysis calculated for $C_{20}H_{24}N_6Cl_2O$:

Theory: C, 55.18; H, 5.56; N, 19.30.

Found: C, 55.11; H, 5.53; N, 19.09.

5

EXAMPLE 71

4-Amino-2-phenylamino-pyrimidine-5-carbonitrile

A solution of aniline (3.31 g) in tetrahydrofuran (40.0 mL) and diisopropylethylamine (4.60 g) was added to a solution of 4-amino-2-chloropyrimidine-5-carbonitrile (5.00 g) in tetrahydrofuran (50.0 mL). The reaction mixture was heated to reflux. After 3 days, additional aniline (6.02 g) and diisopropylethylamine (8.36 g) was added to the reaction. After 24 hours, the reaction mixture was concentrated in vacuo, and the residue was partitioned between ethyl acetate and water. The ethyl acetate layer was washed twice with water then filtered through a fiberglass filter to disperse the emulsion that was present. The filtrate was washed with water then saturated sodium chloride, dried with magnesium sulfate, and concentrated in vacuo. The residue was washed with diethyl ether to give 6.00 g of the title compound, CIMS (1% NH_3 in CH_4): $252 = M^+ + C_3H_5$, $240 = M^+ + C_2H_5$, $212 = M^+ + H$ (Base), $211 = M^+$.

25

Analysis calculated for $C_{11}H_9N_5$:

Theory: C, 62.55; H, 4.29; N, 33.16.

Found: C, 62.85; H, 4.47; N, 33.18.

EXAMPLE 72

30

4-Amino-2-phenylamino-pyrimidine-5-carboxaldehyde

4-Amino-2-phenylamino-pyrimidine-5-carbonitrile (2.00 g) obtained from Example 71 was combined with wet Raney nickel (2.00 g), 98% formic acid (60 mL) and water (40 mL) in a Parr shaker. The reaction was placed under hydrogen (42 psi) and shaken for 20 minutes. The reaction was filtered, and the

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filtrate was concentrated in vacuo. The residue was suspended in water, made basic with saturated sodium bicarbonate, and extracted with ethyl acetate three times. The aqueous layer was filtered through a fiberglass filter to disperse the emulsion that was present. The aqueous filtrate was washed with ethyl acetate. The ethyl acetate washes were combined, filtered, washed with saturated sodium chloride, dried with magnesium sulfate and concentrated in vacuo. Chromatography down silica gel, eluting with ethyl acetate:hexane (2:1) gave 0.73 g of the title compound, CIMS (1% NH₃ in CH₄): 243 = M⁺ + C₂H₅, 215 = M⁺ + H (Base), 214 = M⁺. Analysis calculated for C₁₁H₁₀N₄O:
Theory: C, 61.67; H, 4.71; N, 26.15.
Found: C, 61.79; H, 4.71; N, 26.11.

EXAMPLE 73

6-(2,6-Dichlorophenyl)-N²-phenyl-pyrido[2,3-d]-pyrimidine-2,7-diamine

To a solution of 0.022 g 60% sodium hydride suspension in 2.00 mL of 2-ethoxyethanol was added 0.46 g of 2,6-dichlorophenylacetonitrile and 0.50 g of 4-amino-2-phenylamino-pyrimidine-5-carboxaldehyde from Example 72. The reaction was refluxed for 4 hours, cooled, poured into water, and extracted several times with dichloromethane. The dichloromethane washes were combined, washed with saturated sodium chloride, dried with magnesium sulfate, and concentrated in vacuo. The residue was washed with diethyl ether to give 0.61 g of the title compound, CIMS (1% NH₃ in CH₄): 410 = M⁺ + C₂H₅, 382 = M⁺ + H, 381 = M⁺.

The above compound can be reacted with tert.-butyl isocyanate according to the procedure of Example 52 to give 1-tert.-butyl-3-[[6-(2,6-dichlorophenyl)-2-phenylamino]-pyrido[2,3-d]pyrimidin-7-yl]-urea.

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EXAMPLE 74

4-Amino-2-methylsulfanyl-pyrimidine-5-carboxylic acid ethyl ester

To a suspension of ethyl 4-chloro-2-methylthio-5-pyrimidinecarboxylate (25 g) in ethanol (200 mL) was added 30% ammonium hydroxide (38 mL). After stirring 5 hours at room temperature, the reaction was concentrated in vacuo. The residue was suspended in water and filtered. The filter pad, washed with water then diethyl ether, gave 17.68 g of the title compound, CIMS (1% NH₃ in CH₄): 242 = M⁺ + C₂H₅, 214 = M⁺ + H (Base), 213 = M⁺, 168 = M⁺ - OEt. Analysis calculated for C₈H₁₁N₃SO₂: Theory: C, 45.06; H, 5.20; N, 19.70. Found: C, 44.84; H, 5.14; N, 19.64.

EXAMPLE 75

4-Amino-2-methylsulfanyl-pyrimidin-5-yl)-methanol

Into a suspension of lithium aluminum hydride (1.45 g) in tetrahydrofuran (50 mL) was added dropwise a solution of 4-amino-2-methylsulfanyl-pyrimidin-5-yl)-methanol (5.00 g) from Example 74 in tetrahydrofuran (120 mL). After stirring 1 hour at room temperature, the reaction was quenched with water (1.5 mL), 15% sodium hydroxide (1.5 mL), and finally water again (4.5 mL). The reaction was filtered, and the filter pad was washed with tetrahydrofuran. Concentration of the filtrate in vacuo gave 3.83 g of the title compound, CIMS (1% NH₃ in CH₄): 200 = M⁺ + C₂H₅, 172 = M⁺ + H (Base), 171 = M⁺, 154 = M⁺ - OH.

EXAMPLE 76

4-Amino-2-methylsulfanyl-pyrimidine-5-carboxaldehyde

Into a solution of crude 4-amino-2-methylsulfanyl-pyrimidin-5-yl)-methanol (1.5 g) from Example 76 in chloroform (150 mL) was added manganese dioxide

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(5.67 g) portionwise over 3 minutes. After 6 hours at room temperature, the reaction was filtered through Celite. The filter pad was washed with chloroform then ethyl acetate. The filtrates were combined and concentrated in vacuo to give 1.40 g of the title compound.

EXAMPLE 77

10 6-(2,6-Dichlorophenyl)-2-methylsulfanyl-pyrido-
[2,3-d]pyrimidin-7-ylamine

Into a solution of 2,6-dichlorophenylacetonitrile (0.55 g) in dimethylformamide (5 mL) was added one equivalent of 60% sodium hydride suspension (0.12 g). After 10 minutes, 4-amino-2-methylsulfanyl-pyrimidine-5-carbaldehyde (0.50 g) obtained from Example 76 was added. After stirring overnight at room temperature, the reaction was quenched with water. The aqueous solution was acidified with 1N hydrochloric acid to a pH of 7 and extracted several times with dichloromethane. The combined dichloromethane layers were washed with saturated sodium chloride, dried with magnesium sulfate, and concentrated in vacuo. Chromatography of this residue down silica gel with ethyl acetate:hexane (2:1) gave 0.32 g of the title compound, CIMS (1% NH₃ in CH₄): 365 = M⁺ + C₂H₅, 337 = M⁺ + H (Base), 336 = M⁺.

EXAMPLE 78

30 N'-[6-(2,6-Dichlorophenyl)-2-{3-(diethylamino)propyl-
amino}pyrido[2,3-d]pyrimidin-7-yl]-N,N-dimethylformami-
dine

To a suspension of 210 mg (1 mmol) of 7-amino-6-(2,6-dichlorophenyl)-2-[3-(diethylamino)propylamino]-pyrido[2,3-d]pyrimidine from Example 20 in 0.8 mL of DMF was added 0.8 mL of DMF dimethyl acetal. The mixture was stirred at room temperature for 5.5 hours,

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then concentrated in vacuo. The residual oil was distributed between dichloromethane and water. The organic phase was dried over magnesium sulfate, then concentrated to a glass that was crystallized from acetonitrile to give 160 mg (68%) of N'-[6-(2,6-dichlorophenyl)-2-(3-(diethylamino)propylamino)-pyrido[2,3-d]pyrimidin-7-yl]-N,N-dimethylformamidine, mp 100-104°C.

CIMS (1% ammonia in methane): m/z (relative intensity) 476 (MH⁺ + 2, 60), 474 (MH⁺, 94), 361 (100).

Analysis calculated for C₂₃H₂₉Cl₂N₇·0.4 H₂O:

C, 57.36; H, 6.24; N, 20.36.

Found: C, 57.28; H, 6.05; N, 20.07.

EXAMPLE 79

N'-[7-(3-tert-Butylureido)-6-(2,6-dichlorophenyl)-pyrido[2,3-d]pyrimidin-2-yl]-N,N-dimethylformamidine

1-[2-Amino-6-(2,6-dichlorophenyl)-pyrido[2,3-d]pyrimidin-7-yl]-3-tert-butylurea from Example 3 was reacted with DMF dimethyl acetal for 13.5 hours as described in Example 78. Workup as described above, followed by purification on flash silica gel chromatography eluting sequentially with 100:0, 3:1, 1:1, and 0:100 dichloromethane:ethyl acetate gave a solid that was triturated in 2-propanol to afford the title compound N'-[7-(3-tert-butylureido)-6-(2,6-dichlorophenyl)-pyrido[2,3-d]pyrimidin-2-yl]-N,N-dimethylformamidine, mp 190-193°C.

CIMS (1% ammonia in methane): m/z (relative intensity) 462 (MH⁺ + 2, 0.78), 460 (MH⁺, 0.93).

Analysis calculated for C₂₁H₂₃Cl₂N₇O·0.2 C₃H₈O·0.2 C₃H₇NO:

C, 54.75; H, 5.38 N, 20.71.

Found: C, 54.73; H, 5.31; N, 20.65.

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EXAMPLE 80

N'-[6-(2,6-Dichlorophenyl)-7-[(dimethylamino)methylene-amino]-pyrido[2,3-d]pyrimidin-2-yl]-N,N-dimethylformamidine

5 2,7-Diamino-6-(2,6-dichlorophenyl)-pyrido[2,3-d]-pyrimidine from Example 1 was reacted with DMF dimethyl acetal for 23 hours as described in Example 78. Workup as described above followed by purification on flash silica gel chromatography eluting sequentially with
10 100:0, 9:1, 4:1, and 7:3 ethyl acetate:methanol gave an oil that was crystallized from ethyl acetate to afford N'-[6-(2,6-dichlorophenyl)-7-[(dimethylamino)-methyleneamino]-pyrido[2,3-d]pyrimidin-2-yl]-N,N-dimethylformamidine, mp 269-272°C.
15 CIMS (1% ammonia in methane): m/z (relative intensity) 418 (MH⁺ + 2, 60), 416 (MH⁺, 100).
Analysis calculated for C₁₉H₁₉Cl₂N₇·0.3 H₂O:
 C, 54.11; H, 4.68; N, 23.25.
Found: C, 54.21; H, 4.58; N, 22.89.

20

EXAMPLE 81

6-Phenyl-pyrido[2,3-d]pyrimidine-2,7-diamine

Following the procedure of Example 1, phenylacetonitrile was reacted with 2,4-diamino-5-pyrimidine-carboxaldehyde to give the title compound;
25 mp 317-318°C.

EXAMPLE 82

1-(2-Amino-6-phenyl-pyrido[2,3-d]pyrimidin-7-yl)-3-tert-butyl-urea

30

Following the procedure of Example 2, 0.246 g of 6-phenyl-pyrido[2,3-d]pyrimidine-2,7-diamine from Example 81 was reacted with 0.128 mL of tert-butyl isocyanate. The product is purified by medium pressure chromatography using silica gel and eluting with a
35 gradient of 1:1 CHCl₃:EtOAc to EtOAc to afford the

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title compound; mp >250°C, CIMS (1% ammonia in methane): m/z (relative intensity) 337 (MH⁺ + 1, 64), 338 (MH⁺ + 2, 11), 236 (100).

5

EXAMPLE 83

6-(2,3-Dichlorophenyl)-pyrido[2,3-d]pyrimidine-2,7-diamine

Following the procedure of Example 1, 2,3-dichlorophenylacetonitrile was reacted with 2,4-diamino-5-pyrimidinecarboxaldehyde to give the title compound; mp 366-369°C (dec).

EXAMPLE 84

1-[2-Amino-6-(2,3-dichlorophenyl)-pyrido[2,3-d]-pyrimidin-7-yl]-3-tert-butyl-urea

Following the general procedure of Example 2, 0.502 g of 6-(2,3-dichlorophenyl)-pyrido[2,3-d]-pyrimidine-2,7-diamine from Example 83 was reacted with 0.206 mL of tert-butyl isocyanate. The product is purified by silica gel chromatography eluting with a gradient of CHCl₃:EtOAc (98:2) to CHCl₃:EtOAc (1:2) to afford the title compound; mp 356-358°C. Analysis calculated for C₁₈H₁₈Cl₂N₆O₁·0.05 H₂O: Theory: C, 53.34; H, 4.48; N, 20.74. Found: C, 53.44; H, 4.47; N, 20.29.

EXAMPLE 85

6-(2,3,6-Trichloro-phenyl)-pyrido[2,3-d]pyrimidine-2,7-diamine

The title compound was prepared according to Example 1, starting from 1.0 g of (2,3,6-trichloro)-phenyl-acetonitrile and 0.6 g of 2,4-diamino-5-pyrimidine-carboxaldehyde; mp 320-322°C. Analysis calculated for C₁₃H₈Cl₃N₅: Theory: C, 45.84; H, 2.37; N, 20.56. Found: C, 46.22; H, 2.57; N, 20.54.

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EXAMPLE 86

1-[2-Amino-6-(2,3,6-trichloro-phenyl)-pyrido[2,3-d]-pyrimidin-7-yl]-3-tert-butyl-urea

5 The procedure of Example 2 was followed to react
0.30 g of 6-(2,3,6-trichloro-phenyl)-pyrido[2,3-d]-
pyrimidine-2,7-diamine from Example 85 with tert-butyl
isocyanate (0.108 mL). The product is purified by
medium pressure chromatography (MPLC) using silica gel
and eluting with 1:1 CHCl₃:EtOAc to afford the title
10 compound; mp 329-330°C, CIMS (1% ammonia in methane):
m/z (relative intensity) 439 (MH⁺ - 1, 3), 441
(MH⁺ + 1, 3), 84 (100).

EXAMPLE 87

15 1-[2-Amino-6-(2,6-difluoro-phenyl)-pyrido[2,3-d]-pyrimidin-7-yl]-3-tert-butyl-urea

The title compound was prepared from 0.25 g of
6-(2,6-difluoro-phenyl)-pyrido[2,3-d]pyrimidine-2,7-
diamine from Example 63 and 0.112 mL of tert-butyl
20 isocyanate according to Example 2. The product was
purified by MPLC eluting with a gradient of CHCl₃:EtOAc
(1:1) to EtOAc to afford the pure product; mp >300°C,
CIMS (1% ammonia in methane): m/z (relative intensity)
373 (MH⁺ + 1, 60), 374 (MH⁺ + 2, 10), 274 (100).

25

EXAMPLE 88

1-[2-Amino-6-(2,6-dibromo-phenyl)-pyrido[2,3-d]-pyrimidin-7-yl]-3-tert-butyl-urea

The title compound was prepared from 0.25 g of
30 6-(2,6-dibromo-phenyl)-pyrido[2,3-d]pyrimidine-2,7-
diamine from Example 60 and 0.077 mL of tert-butyl
isocyanate according to Example 2. The product was
purified by MPLC eluting with a gradient of CHCl₃:EtOAc
(1:1) to EtOAc to afford the pure product; mp >300°C
35 (dec).

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Analysis calculated for $C_{18}H_{18}Br_2N_6O_1 \cdot 0.35 H_2O$:

C, 43.20; H, 3.77; N, 16.79; Br, 31.93.

Found: C, 43.53; H, 3.64; N, 16.41; Br, 31.79.

5

EXAMPLE 89

1-[2-Amino-6-(2,6-dichlorophenyl)-pyrido[2,3-d]-
pyrimidin-7-yl]-3-isopropyl-urea

The title compound was prepared from 0.5 g of
6-(2,6-dichlorophenyl)-pyrido[2,3-d]pyrimidine-2,7-
10 diamine from Example 1 and 0.172 mL of isopropyl
isocyanate according to Example 2. The product was
purified by MPLC eluting with a gradient of $CHCl_3$:EtOAc
(1:1) to afford the pure product; mp 184-188°C, CIMS
(1% ammonia in methane): m/z (relative intensity)
15 391 (MH^+ , 16), 393 ($MH^+ + 2$, 11), 306 (100).

EXAMPLE 90

6-o-Tolyl-pyrido[2,3-d]pyrimidine-2,7-diamine

The title compound was prepared according to
20 Example 1, starting from 2-methylbenzyl cyanide and
2,4-diamino-5-pyrimidine-carboxaldehyde; mp 300-302°C.
Analysis calculated for $C_{14}H_{13}N_5$:
Theory: C, 66.92; H, 5.21; N, 27.87.
Found: C, 66.4; H, 5.2; N, 27.9.

25

EXAMPLE 91

1-(2-Amino-6-o-tolyl-pyrido[2,3-d]pyrimidin-7-yl)-
3-tert-butyl-urea

The title compound was prepared from 6-o-tolyl-
30 pyrido[2,3-d]pyrimidine-2,7-diamine from Example 90 and
tert-butyl isocyanate according to Example 2. The
product was purified by MPLC eluting with $CHCl_3$:EtOAc
(1:1) afford the pure product; mp 195-197°C, CIMS (1%
ammonia in methane): m/z (relative intensity)
35 351 ($MH^+ + 1$, 55), 352 ($MH^+ + 2$, 12), 84 (100).

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EXAMPLE 92

6-(2,3-Dimethyl-phenyl)-pyrido[2,3-d]pyrimidine-2,7-diamine

5 The title compound was prepared according to Example 1, starting from 2,3-dimethylphenylacetonitrile and 2,4-diamino-5-pyrimidine-carboxaldehyde; mp 330-333°C.

EXAMPLE 93

10 1-[2-Amino-6-(2,3-dimethyl-phenyl)-pyrido[2,3-d]-pyrimidin-7-yl]-3-tert-butyl-urea

The title compound was prepared from 0.5007 g of 6-(2,3-dimethyl-phenyl)-pyrido[2,3-d]pyrimidine-2,7-diamine from Example 92 and 0.23 mL tert-butyl isocyanate according to Example 2. The product was purified by MPLC eluting with a gradient of CHCl₃:EtOAc (2:1) to CHCl₃:EtOAc (1:1); mp 326-330°C, MS(CI). Analysis calculated for C₂₀H₂₄N₆O₁·0.81 H₂O:
C, 63.38; H, 6.81; N, 22.17.
20 Found: C, 63.54; H, 6.47; N, 21.77.

EXAMPLE 94

6-(3,5-Dimethyl-phenyl)-pyrido[2,3-d]pyrimidine-2,7-diamine

25 The title compound was prepared according to Example 1, starting from 2.0 g of 3,5-dimethylphenylacetonitrile and 1.81 g of 2,4-diamino-5-pyrimidine-carboxaldehyde; mp 298-302°C, MS(CI). Analysis calculated for C₁₅H₁₅N₅:
30 Theory: C, 67.91; H, 5.70; N, 26.40.
Found: C, 67.87; H, 5.75; N, 26.38.

EXAMPLE 95

35 1-[2-Amino-6-(3,5-dimethyl-phenyl)-pyrido[2,3-d]-pyrimidin-7-yl]-3-tert-butyl-urea

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The title compound was prepared from 0.3 g of 6-(3,5-dimethyl-phenyl)-pyrido[2,3-d]pyrimidine-2,7-diamine from Example 94 and 0.14 mL of tert-butyl isocyanate according to Example 2. The product is purified by MPLC eluting with 1:1 CHCl₃:EtOAc; mp 180-182°C, CIMS (1% ammonia in methane): m/z (relative intensity) 365 (MH⁺ + 1, 16), 366 (MH⁺ + 2, 3), 84 (100).

EXAMPLE 96

6-(2,4,6-Trimethyl-phenyl)-pyrido[2,3-d]pyrimidine-2,7-diamine

The title compound was prepared according to Example 1, starting from 0.915 g of 2,4,6-trimethyl-benzyl cyanide and 0.76 g of 2,4-diamino-5-pyrimidine-carboxaldehyde; mp 276-282°C; CIMS (1% ammonia in methane): m/z (relative intensity) 279 (MH⁺, 54), 280 (MH⁺ + 1, 100).

EXAMPLE 97

1-[2-Amino-6-(2,4,6-trimethyl-phenyl)-pyrido[2,3-d]-pyrimidin-7-yl]-3-tert-butyl-urea

The title compound was prepared from 0.25 g of 6-(2,4,6-trimethyl-phenyl)-pyrido[2,3-d]pyrimidine-2,7-diamine from Example 96 and 0.109 mL of tert-butyl isocyanate according to Example 2. The product was purified by medium pressure liquid chromatography eluting with 1:1 CHCl₃:EtOAc; mp 281-297°C; CIMS (1% ammonia in methane): m/z (relative intensity) 379 (MH⁺ + 1, 100), 380 (MH⁺ + 2, 23).

EXAMPLE 98

6-(2,3,5,6-Tetramethyl-phenyl)-pyrido[2,3-d]pyrimidine-2,7-diamine

The title compound was prepared according to Example 1, starting from 1.999 g of 2,3,5,6-trimethyl-

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benzyl cyanide and 1.52 g of 2,4-diamino-5-pyrimidine-carboxaldehyde; mp 327-331°C; CIMS (1% ammonia in methane): m/z (relative intensity) 293 (MH⁺, 65), 294 (MH⁺ + 1, 100).

5

EXAMPLE 99

1-[2-Amino-6-(2,3,5,6-tetramethyl-phenyl)-pyrido-
[2,3-d]pyrimidin-7-yl]-3-tert-butyl-urea

The title compound was prepared from 0.3 g of
10 6-(2,3,5,6-tetramethyl-phenyl)-pyrido[2,3-d]pyrimidine-
2,7-diamine from Example 98 and 0.125 mL of tert-butyl
isocyanate according to Example 2. The product was
purified by medium pressure liquid chromatography
eluting with 1:1 CHCl₃:EtOAc; mp >300°C; CIMS (1%
15 ammonia in methane): m/z (relative intensity)
393 (MH⁺, 55), 394 (MH⁺ + 1, 13), 84 (100).

EXAMPLE 100

20 6-(2-Methoxy-phenyl)-pyrido[2,3-d]pyrimidine-
2,7-diamine

The title compound was prepared according to
Example 1, starting from 2-methoxybenzyl cyanide and
2,4-diamino-5-pyrimidine-carboxaldehyde; mp 304-306°C
(dec).

25 Analysis calculated for C₁₄H₁₃N₅O₁:
Theory: C, 62.91; H, 4.90; N, 26.20.
Found: C, 63.16; H, 5.13; N, 26.42.

EXAMPLE 101

30 1-[2-Amino-6-(2-methoxy-phenyl)-pyrido[2,3-d]pyrimidin-
7-yl]-3-tert-butyl-urea

The title compound was prepared from 0.203 g of
6-(2-methoxy-phenyl)-pyrido[2,3-d]pyrimidine-
2,7-diamine from Example 100 and 0.093 mL of tert-butyl
35 isocyanate according to Example 2. The product was
purified by medium pressure liquid chromatography

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eluting with 1:1 CHCl_3 :EtOAc; mp 300-301°C; CIMS (1% ammonia in methane): m/z (relative intensity)
367 ($\text{MH}^+ + 1$, 67), 368 ($\text{MH}^+ + 2$, 14), 236 (100).

5

EXAMPLE 102

6-(3-Methoxy-phenyl)-pyrido[2,3-d]pyrimidine-2,7-diamine

The title compound was prepared according to Example 1, starting from 3-methoxybenzyl cyanide and
10 2,4-diamino-5-pyrimidine-carboxaldehyde; mp 284-286°C.
Analysis calculated for $\text{C}_{14}\text{H}_{13}\text{N}_5\text{O}_1$:
Theory: C, 62.9; H, 4.9; N, 26.2.
Found: C, 62.8; H, 5.0; N, 26.3.

15

EXAMPLE 103

1-[2-Amino-6-(3-methoxy-phenyl)-pyrido[2,3-d]pyrimidin-7-yl]-3-tert-butyl-urea

The title compound was prepared from 0.50 g of
6-(3-methoxy-phenyl)-pyrido[2,3-d]pyrimidine-
20 2,7-diamine from Example 102 and 0.23 mL tert-butyl
isocyanate according to Example 2. The product was
purified by medium pressure liquid chromatography
eluting with a gradient of CHCl_3 :EtOAc (2:1) to
 CHCl_3 :EtOAc (1:1) to EtOAc; mp 275-280°C; MS(CI).
25 Analysis calculated for $\text{C}_{19}\text{H}_{22}\text{N}_6\text{O}_2 \cdot 0.45 \text{H}_2\text{O}$:
C, 60.93; H, 6.16; N, 22.44.
Found: C, 61.22; H, 5.89; N, 22.09.

30

EXAMPLE 104

6-(2-Bromo-6-chloro-phenyl)-pyrido[2,3-d]pyrimidine-2,7-diamine

Prepared as described in Example 1, starting from
1.0 g of 2-bromo-6-chlorophenylacetonitrile and 0.57 g
of 2,4-diamino-5-pyrimidine-carboxaldehyde,
35 mp 264-280°C; MS(CI).

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Analysis calculated for $C_{13}H_9Cl_1Br_1N_5$:

Theory: C, 44.53; H, 2.59; N, 19.97.

Found: C, 44.48; H, 2.87; N, 20.10.

5

EXAMPLE 105

1-[2-Amino-6-(2-bromo-6-chloro-phenyl)-pyrido[2,3-d]-pyrimidin-7-yl]-3-tert-butyl-urea

The title compound was prepared using 0.30 g of 6-(2-bromo-6-chloro-phenyl)-pyrido[2,3-d]pyrimidine-2,7-diamine from Example 104 and 0.105 mL of tert-butyl isocyanate according to Example 2. The product was purified by MPLC eluting with 1:1 $CHCl_3$:EtOAc; mp 314°C (dec); MS(CI).

Analysis calculated for $C_{18}H_{18}Br_1Cl_1N_6O_1 \cdot 0.43 CHCl_3 \cdot 0.27 C_4H_8O_2$:

15

C, 44.65; H, 3.95; N, 16.01; Br, 15.22;
Cl, 15.47.

Found: C, 44.39; H, 3.96; N, 15.82; Br, 14.83;
Cl, 15.39.

20

EXAMPLE 106

Propane-1-sulfonic acid [2-amino-6-(2,6-dichlorophenyl)-pyrido[2,3-d]pyrimidin-7-yl]-amide

To a slurry of 1.00 g of 2,7-diamino-6-(2,6-dichlorophenyl)-pyrido[2,3-d]pyrimidine from Example 1 in 15 mL of DMF was added 0.15 g sodium hydride (60% in mineral oil) portionwise and the mixture stirred for 1 hour. Propanesulfonyl chloride (0.39 mL) is added dropwise, and the reaction mixture stirred at ambient temperature for 16 hours. The reaction mixture is filtered to remove a small amount of insoluble material and the filtrate evaporated in vacuo. The product is purified by medium pressure liquid chromatography (MPLC) using silica gel and eluting with a gradient of $CHCl_3$:EtOAc (2:1) to $CHCl_3$:EtOAc (1:1) to afford the title compound.

35

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Analysis calculated for $C_{16}H_{15}Cl_2N_5O_2S_1 \cdot 0.25 CHCl_3$:

C, 44.14; H, 3.48; N, 15.84; S, 7.25.

Found: C, 43.92; H, 3.38; N, 15.54; S, 7.04.

5

EXAMPLE 107

6-Pyridin-3-yl-pyrido[2,3-d]pyrimidine-2,7-diamine

The procedure of Example 1 was followed to react 3-pyridylacetonitrile and 2,4-diamino-5-pyrimidine-carboxaldehyde to afford the title compound;

10 mp 317-319°C (dec).

Analysis calculated for $C_{12}H_{10}N_6$:

Theory: C, 60.50; H, 4.23; N, 35.27.

Found: C, 60.5; H, 4.3; N, 35.6.

15

EXAMPLE 108

1-(2-Amino-6-pyridin-3-yl-pyrido[2,3-d]pyrimidin-7-yl)-3-tert-butyl-urea

By following the procedure of Example 2, 0.30 g of 2,7-diamino-6-(3-pyridyl)-pyrido[2,3-d]pyrido[2,3-d]-
20 pyrimidine from Example 107 was reacted with 0.16 mL of tert-butyl isocyanate. The product was purified by medium pressure chromatography using silica gel and eluting with 90:10:1 EtOAc:MeOH:TEA to afford the title
compound; mp >300°C; CIMS (1% ammonia in methane): m/z
25 (relative intensity) 338 ($MH^+ + 1$, 8), 339 ($MH^+ + 2$, 1), 84 (100).

EXAMPLE 109

6-Pyridin-4-yl-pyrido[2,3-d]pyrimidine-2,7-diamine

30

To cooled (0°C) 2-ethoxyethanol (13 mL) was added portionwise 0.30 g of sodium hydride (60% in mineral oil), and the suspension was stirred for 10 minutes. To this suspension was added 1.06 g of 4-pyridylacetonitrile hydrochloride, and the mixture was stirred at
35 room temperature for 30 minutes. The neutralized solution of 4-pyridylacetonitrile in 2-ethoxyethanol

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was added to a reaction mixture containing sodium
2-ethoxyethoxide (prepared from 0.11 g of sodium
hydride and 4.76 mL of 2-ethoxyethanol) and 0.9 g of
2,4-diamino-5-pyrimidinecarboxaldehyde. The resulting
mixture was heated at reflux for 2 hours, cooled, and
the insoluble product washed with diethylether and
ethyl acetate to afford the title compound; mp >340°C;
MS (CI).

Analysis calculated for $C_{12}H_{10}N_6 \cdot 0.05 H_2O$:

C, 60.27; H, 4.26; N, 35.14.

Found: C, 60.35; H, 4.31; N, 34.75.

EXAMPLE 110

1-(2-Amino-6-pyridin-4-yl-pyrido[2,3-d]pyrimidin-7-yl)-
3-tert-butyl-urea

Following the procedure of Example 2, 0.30 g of
2,7-diamino-6-(4-pyridyl)-pyrido[2,3-d]pyrimidine from
Example 109 was reacted with 0.154 mL of tert-butyl
isocyanate. The product was purified by medium
pressure chromatography using silica gel and eluting
with 90:10:1 EtOAc:MeOH:TEA, to afford the title
compound, mp >350°C; CIMS (1% ammonia in methane): m/z
(relative intensity) 338 ($MH^+ + 1$, 6), 339 ($MH^+ + 2$,
1), 84 (100).

EXAMPLE 111

6-Pyridin-2-yl-pyrido[2,3-d]pyrimidine-2,7-diamine

The procedure of Example 1 was followed to react
0.84 mL of 2-pyridylacetonitrile and 1.0 g of
2,4-diamino-5-pyrimidinecarboxaldehyde to afford the
title compound, mp 312-321°C.

Analysis calculated for $C_{12}H_{10}N_6 \cdot 0.07 H_2O$:

C, 60.18; H, 4.27; N, 35.09.

Found: C, 60.46; H, 4.34; N, 34.70.

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EXAMPLE 112

1-[6-(2,6-Dichlorophenyl)-2-(3-diethylamino-propyl-amino)-pyrido[2,3-d]pyrimidin-7-yl]-3-ethyl-urea

By following the general procedure of Example 21,
5 0.85 g of 7-amino-6-(2,6-dichlorophenyl)-2-(3-diethyl-amino-propylamino)-pyrido[2,3-d]pyrimidine from
Example 20 was reacted with 0.176 mL of ethyl
isocyanate. The product was purified by reverse phase
preparative HPLC on a C18 reverse phase column, eluting
10 with a solvent gradient starting from 90% of 0.1%
trifluoroacetic acid in water/10% of 0.1%
trifluoroacetic acid in acetonitrile to 60% of 0.1%
trifluoroacetic acid in water/40% of 0.1%
trifluoroacetic acid in acetonitrile, mp 92-108°C.
15 Analysis calculated for $C_{23}H_{29}Cl_2N_7O_1 \cdot 0.25 H_2O$:
C, 55.82; H, 6.01; N, 19.81.
Found: C, 55.84; H, 6.02; N, 19.68.

EXAMPLE 113

20 1-[6-(2,6-Dichlorophenyl)-2-(3-diethylamino-propyl-amino)-pyrido[2,3-d]pyrimidin-7-yl]-3-isopropyl-urea

The procedure of Example 21 was followed to react
0.30 g of 7-amino-6-(2,6-dichlorophenyl)-2-(3-diethyl-amino-propylamino)-pyrido[2,3-d]pyrimidine from
25 Example 20 and 0.077 mL of isopropyl isocyanate. The
product was purified by medium pressur  chromatography
on silica gel eluting with 90:10:1 EtOAc:MeOH:TEA to
afford the title compound, mp 88-100°C; CIMS (1%
ammonia in methane): m/z (relative intensity)
30 504 (MH^+ , 3), 506 ($MH^+ + 2$, 2), 86 (100).

EXAMPLE 114

N²-(3-Diethylamino-propyl)-6-(2,6-dimethyl-phenyl)-pyrido[2,3-d]pyrimidine-2,7-diamine

35 The procedure of Example 20 was followed to react
3.0 g of 2,7-Diamino-6-(2,6-dimethylphenyl)pyrido-

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[2,3-d]pyrimidine from Example 6 and 30 mL of 1-amino-3-(N,N-diethylamino)propane to give the title compound, mp 216-219°C.

Analysis calculated for $C_{22}H_{30}N_6 \cdot 0.15 H_2O$:

5 C, 69.31; H, 8.01; N, 22.04.

Found: C, 69.29; H, 7.89; N, 22.04.

EXAMPLE 115

10 1-[2-(3-Dimethylamino-propylamino)-6-(2,6-dimethyl-phenyl)-pyrido[2,3-d]pyrimidin-7-yl]-3-ethyl-urea

Prepared as described in Example 21, starting from 7-amino-6-(2,6-dimethylphenyl)-2-(3-diethylamino-propylamino)-pyrido[2,3-d]pyrimidine from Example 114 and ethyl isocyanate. The product was purified by reverse phase preparative HPLC on a C18 reverse phase column, eluting with a solvent gradient starting from 100% of 0.1% trifluoroacetic acid in water/0% of 0.1% trifluoroacetic acid in acetonitrile to 70% of 0.1% trifluoroacetic acid in water/30% of 0.1% trifluoroacetic acid in acetonitrile, mp 64-70°C.

20 Analysis calculated for $C_{25}H_{35}N_7O_1 \cdot 0.35 H_2O$:

C, 65.86; H, 7.89; N, 21.51.

Found: C, 65.78; H, 7.63; N, 21.39.

25 EXAMPLE 116

1-tert-Butyl-3-[2-(3-diethylamino-propylamino)-6-(2,6-dimethyl-phenyl)-pyrido[2,3-d]pyrimidin-7-yl]-urea

Prepared as described in Example 21, starting from 0.50 g of 7-amino-6-(2,6-dimethylphenyl)-2-(3-diethyl-amino-propylamino)-pyrido[2,3-d]pyrimidine from Example 114 and 0.17 mL of tert-butyl isocyanate. The product was purified by reverse phase preparative HPLC on a C18 reverse phase column, eluting with a solvent gradient starting from 95% of 0.1% trifluoroacetic acid in water/5% of 0.1% trifluoroacetic acid in acetonitrile to 65% of 0.1% trifluoroacetic acid in

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water/35% of 0.1% trifluoroacetic acid in acetonitrile,
mp 86-91°C.

Analysis calculated for $C_{27}H_{39}N_7O_1$:

Theory: C, 67.89; H, 8.23; N, 20.53.

5 Found: C, 67.70; H, 8.24; N, 20.43.

EXAMPLE 117

10 1-Adamantan-1-yl-3-(6-(2,6-dichlorophenyl)-2-[3-(4-methyl-piperazin-1-yl)-propylamino]-pyrido[2,3-d]-pyrimidin-7-yl)-urea

Prepared as described above in Example 37 starting from 0.5 g of N^2 -[3-(4-methyl-piperazin-1-yl)-propyl]-6-(2,6-dichlorophenyl)-pyrido[2,3-d]pyrimidine-2,7-diamine from Example 36 and 0.218 g of 1-adamantyl isocyanate. The product was purified by medium pressure chromatography using silica gel and eluting with 90:10:1 EtOAc:MeOH:TEA, to afford the title compound, mp >200°C (dec); ESMS (20/80 MeOH/CH₃CN + 0.1% AcOH): m/z (relative intensity) 623.4 (MH⁺, 100), 625.5 (MH⁺ + 2, 48).

20 Analysis calculated for $C_{32}H_{40}Cl_2N_8O_1 \cdot 0.52 H_2O$:

C, 60.72; H, 6.54; N, 17.70.

Found: C, 61.06; H, 6.58; N, 17.30.

25

EXAMPLE 118

1-tert-Butyl-3-(6-(2,6-dichlorophenyl)-2-[3-(4-methyl-piperazin-1-yl)-propylamino]-pyrido[2,3-d]pyrimidin-7-yl)-thiourea

30 Prepared as described above in Example 37 starting from 0.5 g of N^2 -[3-(4-methyl-piperazin-1-yl)-propyl]-6-(2,6-dichlorophenyl)-pyrido[2,3-d]pyrimidine-2,7-diamine from Example 36 and 0.142 g of tert-butyl isothiocyanate. The product was purified by medium pressure chromatography using silica gel and eluting with 90:10:1 EtOAc:MeOH:TEA which gave a mixture of two products. The mixture was further purified by reverse

35

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phase preparative HPLC on a C18 reverse phase column, eluting with a solvent gradient starting from 95% of 0.1% trifluoroacetic acid in water/5% of 0.1% trifluoroacetic acid in acetonitrile to 65% of 0.1% trifluoroacetic acid in water/35% of 0.1% trifluoroacetic acid in acetonitrile, mp >200°C (dec); MS (ES).

EXAMPLE 119

10 3-{6-(2,6-Dichlorophenyl)-2-[3-(4-methyl-piperazin-1-yl)-propylamino]-pyrido[2,3-d]pyrimidin-7-yl}-1,1-diethyl-urea

To a solution of 0.50 g of N²-[3-(4-methyl-piperazin-1-yl)-propyl]-6-(2,6-dichlorophenyl)-pyrido[2,3-d]pyrimidine-2,7-diamine from Example 36 in 5 mL DMF was added 0.10 g of 60% sodium hydride, and the mixture stirred for 1 hour at room temperature. The suspension was cooled to 0°C and 0.15 mL of diethylcarbonyl chloride was added dropwise. After the addition was completed, the reaction mixture was allowed to warm to room temperature and stirred for 18 hours at ambient temperature. The mixture was concentrated in vacuo and the product purified by medium pressure chromatography on silica gel eluting with 90:10:1 EtOAc:MeOH:TEA to afford the title compound, mp >200°C (dec); MS (ES).

EXAMPLE 120

30 N²-[3-(4-Methyl-piperazin-1-yl)-propyl]-6-(2,3,5,6-tetramethyl-phenyl)-pyrido[2,3-d]pyrimidine-2,7-diamine

A mixture of 1.00 g of 6-(2,3,5,6-tetramethyl-phenyl)-pyrido[2,3-d]pyrimidine-2,7-diamine from Example 98, 0.66 g of sulfamic acid, and 10 mL of 1-(3-aminopropyl)-4-methyl piperazine was heated to reflux with stirring for 34 hours. The reaction flask was fitted with a short path distillation column and the

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excess amine removed by distillation under high vacuum. The residue was diluted with 40 mL of dichloromethane, washed with 10 mL of water followed by a 15 mL wash with saturated sodium bicarbonate. The basic aqueous layer was extracted with dichloromethane (3 x 25 mL), and the combined organic layers back washed with brine (3 x 25 mL). The organic layer was dried over magnesium sulfate, filtered, and evaporated in vacuo. The product was purified by medium pressure chromatography using silica gel and eluting with 90:10:1 EtOAc:MeOH:TEA, to afford the titled compound, mp 218-223°C; MS(APCI). Analysis calculated for $C_{25}H_{35}N_7 \cdot 0.30 C_4H_8O_2$:
C, 68.41; H, 8.19; N, 21.31.
Found: C, 68.05; H, 7.95; N, 21.70.

EXAMPLE 121

1-tert-Butyl-3-(2-[3-(4-methyl-piperazin-1-yl)-propylamino]-6-(2,3,5,6-tetramethyl-phenyl)-pyrido[2,3-d]pyrimidin-7-yl)-urea

Prepared as described in Example 37 starting from 0.41 g of N^2 -[3-(4-methyl-piperazin-1-yl)-propyl]-6-(2,3,5,6-tetramethyl-phenyl)-pyrido[2,3-d]pyrimidine-2,7-diamine from Example 120 and 0.12 mL of tert-butyl isocyanate. The product was purified by medium pressure chromatography using silica gel and eluting with 90:10:1 EtOAc:MeOH:TEA to afford the title compound, mp 185-198°C.

Analysis calculated for $C_{30}H_{44}N_8O_1$:
Theory: C, 67.64; H, 8.33; N, 21.03.
Found: C, 67.31; H, 8.23; N, 20.87.

EXAMPLE 122

1-[6-(2,6-Dichlorophenyl)-2-(4-diethylamino-butylamino)-pyrido[2,3-d]pyrimidin-7-yl]-3-(3-morpholin-4-yl-propyl)-thiourea

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Prepared as described in Example 37 starting from 0.3926 g of N²-[3-(4-methyl-piperazin-1-yl)-propyl]-6-(2,6-dichlorophenyl)-pyrido[2,3-d]pyrimidine-2,7-diamine from Example 53 and 0.18 g of 3-morpholinopropyl isothiocyanate. The product was purified by medium pressure chromatography on silica gel and eluting with a solvent mixture of 90:10:1 EtOAc:MeOH:TEA to afford the title compound; mp >200°C (dec); ESMS (20/80 MeOH/CH₃CN + 0.1% AcOH): m/z (relative intensity) 619.4 (MH⁺, 100), 621.5 (MH⁺ 2, 77).

EXAMPLE 123

1-tert-Butyl-3-[6-(2,6-dichlorophenyl)-2-(4-diethylamino-butylamino)-pyrido[2,3-d]pyrimidin-7-yl]-urea

To a solution of 6-(2,6-dichlorophenyl)-N²-(4-diethylamino-butyl)-pyrido[2,3-d]pyrimidine-2,7-diamine (25.0 g) from Example 53 in DMF (300 mL) was added 1 equivalent of 60% sodium hydride suspension (2.31 g). After stirring for approximately 2 hours at room temperature, one equivalent of phenyl isocyanate (5.72 g) was added and the reaction monitored by thin layer chromatography. After approximately 24 hours, the solvent was removed in vacuo. The residue was dissolved in dichloromethane and this solution was washed several times, first with water and then a saturated solution of sodium chloride. The dichloromethane layer was dried with magnesium sulfate and concentrated in vacuo. Chromatography of the residue on silica gel eluting with ethyl acetate: ethanol:triethylamine (9:2:1), followed by crystallization from tert-butyl methyl ester gave 21.58 g of the title compound 1-tert-butyl-3-[6-(2,6-dichlorophenyl)-2-(4-diethylamino-butylamino)-pyrido[2,3-d]pyrimidin-7-yl]-urea, ESMS (20/80 MeOH/CH₃CN + 0.1% AcOH): M⁺ + H = 532; mp dec 157°C.

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Analysis calculated for $C_{26}H_{35}N_7Cl_2O \cdot 0.10 H_2O$:

Theory: C, 58.45; H, 6.64; N, 18.35; Cl, 13.27;
H₂O, 0.34.

Found: C, 58.51; H, 6.75; N, 18.37; Cl, 13.17;
H₂O, 0.57.

5

EXAMPLE 124

1-[6-(2,6-Dichlorophenyl)-2-(4-diethylamino-butyl-
amino)-pyrido[2,3-d]pyrimidin-7-yl]-3-ethyl-urea

10 To a cooled (5°C) solution of 6-(2,6-
dichlorophenyl)-N²-(4-diethylamino-butyl)-
pyrido[2,3-d]pyrimidine-2,7-diamine (0.61 g) from
Example 53 in THF (6 mL) was added potassium
15 hexamethyldisilazane (0.308 g) in portions. The
reaction mixture was allowed to warm to ambient
temperature and stirred for 30 minutes. Then ethyl
isocyanate was added, and the reaction mixture was
stirred for an additional 18 hours at ambient
20 temperature. The product was isolated by pouring the
reaction mixture into approximately 200 mL of 0.25N
aqueous HCl and filtering the resulting solution. The
filtrate was made basic with 50% aqueous sodium
hydroxide, and the aqueous layer was extracted twice
25 with ethyl acetate. The combined organic extracts were
dried (MgSO₄), filtered, and the filtrate concentrated
under vacuum. The product was purified by radial
chromatography eluting with a solvent mixture of
90:10:1 EtOAC:MeOH:TEA to afford the title compound.
Analysis calculated for $C_{24}H_{31}Cl_2N_7O_1 \cdot 0.78 H_2O$:
30 C, 55.59; H, 6.33; N, 18.91.
Found: C, 55.59; H, 5.93; N, 18.62.

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EXAMPLE 125

N-[6-(2,6-Dichlorophenyl)-2-(3-diethylamino-propyl-amino)-pyrido[2,3-d]pyrimidin-7-yl-N']-ethyl-guanidine

To a solution of 7-amino-6-(2,6-dichlorophenyl)-2-(3-diethylamino-propylamino)-pyrido[2,3-d]pyrimidine (42 mg) from Example 20 in DMF (1 mL) was added 60% sodium hydride suspension (5 mg), and the mixture was stirred at room temperature for 0.5 hour. To the reaction mixture was added *N,N'*-Bis(*tert*-butoxy-carbonyl)-*N*-(ethyl)-*S*-(ethyl)isothiourea (37 mg), and the mixture was stirred for 18 hours. The reaction mixture was diluted with dichloromethane (50 mL) and washed with water (2 × 15 mL). The organic layer was dried with sodium sulfate and concentrated. The resulting oil was purified on silica gel, eluting with methanol:ethyl acetate:triethylamine (8.5:1.5:0.3) to afford a mixture of 7-amino-6-(2,6-dichlorophenyl)-2-(3-diethylamino-propylamino)-pyrido[2,3-d]pyrimidine (40 mg) and [[6-(2,6-dichlorophenyl)-2-(3-diethylamino-propylamino)-pyrido[2,3-d]pyrimidin-7-yl]imino[[1,1-dimethylethoxy)carbonyl]amino]methyl]-ethylamino]carbamic acid-1,1-dimethylethyl ester. This mixture was dissolved in anhydrous dichloromethane (0.5 mL) containing 2,6-lutidine (8 mg). Trimethylsilyl trifluoromethanesulfonate (6 mg) was added, and the mixture was stirred at room temperature for 30 hours. The mixture was poured into saturated aqueous sodium bicarbonate, extracted with dichloromethane, dried over sodium sulfate, and concentrated. The resulting oil was chromatographed on silica gel, eluting with methanol:ethyl acetate:triethylamine (8.5:1.5:0.3) to afford the title compound (7 mg), ESMS (1/4 MeOH/CH₃CN + 0.1% AcOH): *m/z* (relative intensity) 490.5 (MH⁺, 100), 491.5 (MH⁺ + 1, 27), 492.5 (MH⁺ + 2, 64).

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The following examples further illustrate typical pharmaceutical formulations provided by this invention.

EXAMPLE 126

5 A pharmaceutical formulation in the form of hard gelatin capsules for oral administration are prepared using the following ingredients:

	Quantity (mg/capsule)
10 Active compound	250
Starch powder	200
Magnesium stearate	10
Total	460 mg

15

The above ingredients are mixed and filled into hard gelatin capsules in 460 mg quantities. A typical active ingredient is N-[2-formylamino-6-(3,5-dimethyl-phenyl)-pyrido[2,3-d]pyrimidin-7-yl]-n-butyamide. The composition is administered from 2 to 4 times a day for treatment of postsurgical restenosis.

20

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EXAMPLE 127

Formulation for Oral Suspension

	Ingredient	Amount
5	3-(4,5-dibromophenyl)-[1,6]- naphthyridine-2,7-diamine	500 mg
	Sorbitol solution (70% N.F.)	40 mL
	Sodium benzoate	150 mg
	Saccharin	10 mg
10	Cherry Flavor	50 mg
	Distilled water q.s. ad	100 mL

15 The sorbitol solution is added to 40 mL of
distilled water and the naphthyridine is suspended
therein. The saccharin, sodium benzoate, and flavoring
are added and dissolved. The volume is adjusted to
100 mL with distilled water. Each milliliter of syrup
contains 5 mg of active ingredient.

20

EXAMPLE 128

Tablets each containing 60 mg of active ingredient

	Active ingredient	60 mg
25	Starch	45 mg
	Microcrystalline cellulose	35 mg
	Polyvinylpyrrolidone (as 10% solution in water)	4 mg
	Sodium carboxymethyl starch	4.5 mg
30	Magnesium stearate	0.5 mg
	Talc	1.0 mg
	Total	150 mg

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The active ingredients, starch, and cellulose, are passed through a No. 45 mesh U.S. sieve and mixed thoroughly. The solution of polyvinylpyrrolidone is mixed with the resultant powders and then passed through a No. 14 mesh U.S. sieve. The granules are dried at 50-60°C and passed through a No. 18 mesh U.S. sieve. The sodium carboxymethyl starch, magnesium stearate, and talc, previously passed through a No. 60 mesh U.S. sieve, are then added to the granules which, after mixing, are compressed on a tablet machine to yield tablets each weighing 150 mg.

A typical active ingredient utilized in the above preparation is the compound of Example 21.

15

EXAMPLE 129

A parenteral composition suitable for administration by injection is prepared by dissolving 100 mg of 1-[2-amino-6-(2,6-dichlorophenyl)-pyrido-[2,3-d]pyrimidin-7-yl]-3-(3-morpholin-4-yl-propyl)-thiourea in 250 mL of 0.9% aqueous sodium chloride solution and adjusting the pH of the solution to about 7.0. This formulation is well suited for the treatment of breast cancer.

25

EXAMPLE 130

Preparation for Suppositories

A mixture of 500 mg of 1-[2-amino-6-(2,6-dichlorophenyl)-pyrido[2,3-d]pyrimidin-7-yl]-imidazolidin-2-one and 1500 mg of theobroma oil are blended to uniformity at 60°C. The mixture is cooled to 24°C in tapered molds. Each suppository will weigh about 2 g and can be administered from 1 to 2 times each day for treatment of bacterial infections.

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EXAMPLE 131

Topical Preparation		
	Ingredient	Amount (mg)
5	N ¹ -(3-methylaminopropyl)-6-(3,5-dimethoxyphenyl)-pyrido[2,3-d]pyrimidine-2,7-diamine	20
	Propylene Glycol	100
10	White Petrolatum	500
	Cetearyl Alcohol	50
	Glyceryl Stearate	100
	PEG 100 Stearate	100
	Ceteth-20	50
15	Monobasic Sodium Phosphate	80
	TOTAL	1000

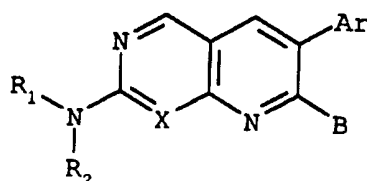
What is claimed is:

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CLAIMS

1. A compound of Formula I

5



I

wherein

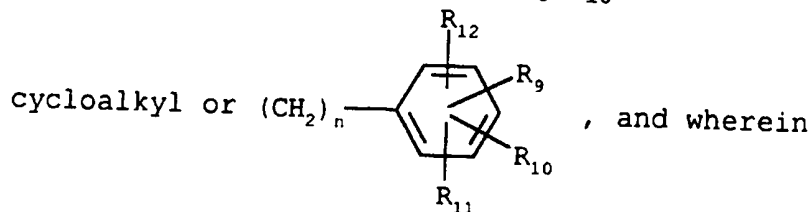
10

X is CH or N;

B is halo, hydroxy, or NR_3R_4 ;

R_1 , R_2 , R_3 , and R_4 independently are hydrogen, $\text{C}_1\text{-C}_8$ alkyl, $\text{C}_2\text{-C}_8$ alkenyl, $\text{C}_2\text{-C}_8$ alkynyl, Ar' , amino, $\text{C}_1\text{-C}_8$ alkylamino or di- $\text{C}_1\text{-C}_8$ alkylamino; and wherein the alkyl, alkenyl, and alkynyl groups may be substituted by NR_5R_6 , where R_5 and R_6 are independently hydrogen, $\text{C}_1\text{-C}_8$ alkyl, $\text{C}_2\text{-C}_8$ alkenyl, $\text{C}_2\text{-C}_8$ alkynyl, $\text{C}_3\text{-C}_{10}$

20



25

any of the foregoing alkyl, alkenyl, and alkynyl groups may be substituted with hydroxy or a 5- or 6-membered carbocyclic or heterocyclic ring containing 1 or 2 heteroatoms selected from nitrogen, oxygen, and sulfur, and R_9 , R_{10} , R_{11} , and R_{12} independently are hydrogen, nitro, trifluoromethyl, phenyl, substituted phenyl, $\text{-C}\equiv\text{N}$,

30

-COOR_8 , -COR_8 , -CR_8 , $\text{-C(R}_8\text{)NH}$, SO_2R_8 , halo, $\text{C}_1\text{-C}_8$ alkyl, $\text{C}_1\text{-C}_8$ alkoxy, thio, $\text{-S-C}_1\text{-C}_8$ alkyl, hydroxy, $\text{C}_1\text{-C}_8$ alkanoyl, $\text{C}_1\text{-C}_8$ alkanoyloxy, or

35

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-NR₅R₆, or R₉ and R₁₀ taken together when adjacent can be methylenedioxy; n is 0, 1, 2, or 3; and wherein R₅ and R₆ together with the nitrogen to which they are attached can complete a ring having 3 to 6 carbon atoms and optionally containing a heteroatom selected from nitrogen, oxygen, and sulfur;

R₁ and R₂ together with the nitrogen to which they are attached, and R₃ and R₄ together with the nitrogen to which they are attached, can also be

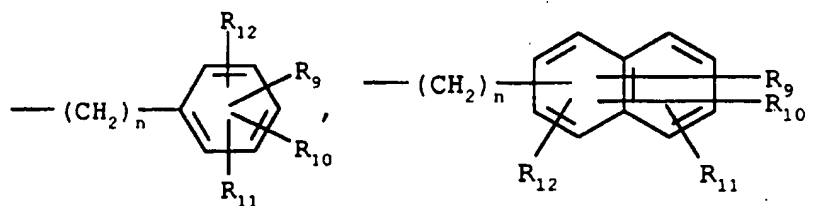
(H, CH₃, or NH₂)

-N=C-R₈ or can complete a ring having 3 to 6 carbon atoms and optionally containing 1 or 2 heteroatoms selected from nitrogen, oxygen, and sulfur, and R₁ and R₃ additionally can be an acyl

analog selected from $\begin{array}{c} \text{O} \\ \parallel \\ -\text{C}-\text{R}_8 \end{array}$, $\begin{array}{c} \text{O} \\ \parallel \\ -\text{C}-\text{OR}_8 \end{array}$, $\begin{array}{c} \text{S} \\ \parallel \\ -\text{C}-\text{R}_8 \end{array}$,

$\begin{array}{c} \text{NH} \\ \parallel \\ -\text{C}-\text{R}_8 \end{array}$, $\begin{array}{c} \text{O} \\ \parallel \\ -\text{S}-\text{R}_8 \\ \parallel \\ \text{O} \end{array}$, or $\begin{array}{c} \text{(O)}^{0 \text{ or } 1} \\ \parallel \\ \text{N} \end{array} \text{---} (\text{CH}_2)_{1,2, \text{ or } 3}$

in which R₈ is hydrogen, C₁-C₈ alkyl, C₂-C₈ alkenyl, C₂-C₈ alkynyl, C₃-C₁₀ cycloalkyl optionally containing an oxygen, nitrogen, or sulfur atom,



and -NR₅R₆, and wherein the R⁸ alkyl, alkenyl, and alkynyl groups can be substituted by NR₅R₆;

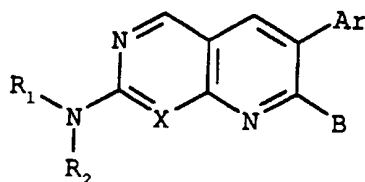
Ar and Ar' are unsubstituted or substituted aromatic or heteroaromatic groups selected from phenyl, imidazolyl, pyrrolyl, pyridyl, pyrimidyl,

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benzimidazolyl, benzothienyl, benzofuranyl,
indolyl, pyrazinyl, thiazolyl, oxazolyl,
isoxazolyl, furanyl, thienyl, naphthyl, wherein
the substituents are R_9 , R_{10} , R_{11} , and R_{12} as
defined above;

and the pharmaceutically acceptable acid and
base addition salts thereof; provided that when X
is N and B is NR_3R_4 , one of R_3 and R_4 is other
than hydrogen.

2. A compound of Claim 1 having the formula

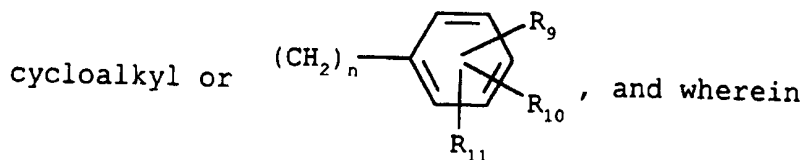


wherein

X is CH or N;

B is halo, hydroxy, or NR_3R_4 ;

R_1 , R_2 , R_3 , and R_4 independently are
hydrogen, C_1 - C_6 alkyl, C_2 - C_6 alkenyl, C_2 - C_6
alkynyl, amino, C_1 - C_6 alkylamino or di- C_1 - C_6
alkylamino; and wherein the alkyl, alkenyl, and
alkynyl groups may be substituted by NR_5R_6 , where
 R_5 and R_6 are independently hydrogen, C_1 - C_6 alkyl,
 C_2 - C_6 alkenyl, C_2 - C_6 alkynyl, C_3 - C_6



any of the alkyl, alkenyl, and alkynyl groups may
be substituted with a 5- or 6-membered carbocyclic
or heterocyclic ring containing 1 or 2 heteroatoms
selected from nitrogen, oxygen, and sulfur, and

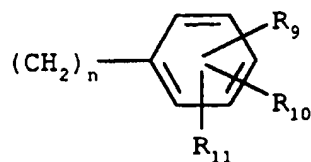
-117-

R_9 , R_{10} , and R_{11} independently are hydrogen, nitro, trifluoromethyl, phenyl, substituted phenyl, $-C\equiv N$,

30 $-COOR_8$, $-COR_8$, $-CR_8$, $-C(R_8)NH$, SO_2R_8 , halo, C_1-C_6 alkyl, C_1-C_6 alkoxy, thio, $-S-C_1-C_6$ alkyl, hydroxy, C_1-C_6 alkanoyl, C_1-C_6 alkanoyloxy, or $-NR_5R_6$, or R_9 and R_{10} taken together when adjacent
35 can be methylenedioxy; n is 0, 1, 2, or 3; and wherein R_5 and R_6 together with the nitrogen to which they are attached can complete a ring having 3 to 6 carbon atoms and optionally containing a heteroatom selected from nitrogen, oxygen, and
40 sulfur;

R_1 and R_2 together with the nitrogen to which they are attached, and R_3 and R_4 together with the nitrogen to which they are attached, can complete a ring having 3 to 6 carbon atoms and optionally
45 containing a heteroatom selected from nitrogen, oxygen, and sulfur, and R_1 and R_3 additionally can

be an acyl selected from $-C(=O)R_8$, $-C(=O)OR_8$, $-C(=S)R_8$,
50 $-C(=NH)R_8$, $-S(=O)_2R_8$, in which R_8 is hydrogen, C_1-C_6 alkyl, C_2-C_6 alkenyl, C_2-C_6 alkynyl, C_3-C_6 cycloalkyl,
55



and $-NR_5R_6$, and wherein the

60 alkyl, alkenyl, and alkynyl groups can be substituted by NR_5R_6 ;

Ar is an unsubstituted or substituted aromatic or heteroaromatic group selected from
65 phenyl, imidazolyl, pyrrolyl, pyridyl, pyrimidyl,

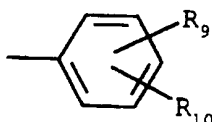
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70 benzimidazolyl, benzothienyl, benzofuranyl, indolyl, pyrazinyl, thiazolyl, oxazolyl, isoxazolyl, furanyl, thienyl, naphthyl, wherein the substituents are R_9 , R_{10} , and R_{11} as defined above;

and the pharmaceutically acceptable acid and base addition salts thereof; provided that when X is N and B is NR_3R_4 , one of R_3 and R_4 is other than hydrogen.

3. A compound of Claim 1 wherein B is halo or hydroxy.
4. A compound of Claim 1 wherein B is NR_3R_4 .
5. A compound of Claim 4 wherein X is CH.
6. A compound of Claim 5 wherein Ar is an optionally substituted phenyl ring of the formula

5



7. A compound of Claim 6 wherein R_2 and R_4 are hydrogen.
8. A compound of Claim 7 wherein R_1 and R_3

5

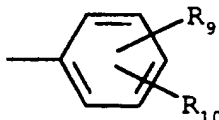
independently are hydrogen, C_1 - C_6 alkyl, $\begin{array}{c} \text{S} \\ | \\ -\text{C}-\text{R}_8 \end{array}$ or $\begin{array}{c} \text{O} \\ || \\ -\text{C}-\text{R}_8 \end{array}$.

9. A compound of Claim 8 wherein R_8 is C_1 - C_6 alkyl, $-NR_5R_6$, or C_1 - C_6 alkyl- NR_5R_6 .

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10. A compound of Claim 9 wherein R_5 and R_6 independently are hydrogen, C_1 - C_6 alkyl, or C_1 - C_6 alkyl NR_5R_6 .
11. The compound of Claim 8 which is 3-o-tolyl-[1,6]naphthyridine-2,7-diamine.
12. The compound of Claim 8 which is 3-(2-chlorophenyl)-[1,6]naphthyridine-2,7-diamine.
13. A compound of Claim 5 wherein Ar is an optionally substituted heteroaromatic ring.
14. A compound of Claim 4 wherein X is N.
15. A compound of Claim 14 wherein Ar is an optionally substituted phenyl ring of the formula

5



16. A compound of Claim 15 wherein R_2 and R_4 are hydrogen.
17. A compound of Claim 16 wherein R_1 and R_3 independently are hydrogen, C_1 - C_6 alkyl, $-C(R_7)(R_8)-R_8$, or $-C(R_7)(R_8)-R_8$.
18. A compound of Claim 17 wherein R_8 is C_1 - C_6 alkyl, $-NR_5R_6$, or $-C_1$ - C_6 alkyl- NR_5R_6 .
19. A compound of Claim 18 wherein R_5 is hydrogen and R_6 is C_1 - C_6 alkyl or C_1 - C_6 alkyl NR_5R_6 .

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20. A compound of Claim 19 selected from the group consisting of:

- 5 1-tert-Butyl-3-[7-(3-tert-butylureido)-
6-(2,6-dichlorophenyl)-pyrido[2,3-d]pyrimidin-
2-yl]urea;
- 1-[2-Amino-6-(2,6-dichlorophenyl)-
pyrido[2,3-d]pyrimidin-7-yl]-3-tert-butylurea;
- 1-tert-Butyl-3-[7-(3-tert-butylureido)-
6-o-tolyl-pyrido[2,3-d]pyrimidin-2-yl]urea;
- 10 1-[2-Amino-6-o-tolyl-pyrido[2,3-d]pyrimidin-
7-yl]-3-tert-butylurea;
- 1-[2-Amino-6-(2,6-dimethylphenyl)-
pyrido[2,3-d]pyrimidin-7-yl]-3-tert-butylurea;
- N-[2-Acetylamino-6-(2,6-dichlorophenyl)-
pyrido[2,3-d]pyrimidin-7-yl]-acetamide;
- 15 N⁷-Butyl-6-phenyl-pyrido[2,3-d]pyrimidine-
2,7-diamine;
- 1-[2-Amino-6-(2,6-dichlorophenyl)-
pyrido[2,3-d]pyrimidin-7-yl]-3-ethylurea;
- 20 N²,N⁷-Dimethyl-6-phenyl-pyrido[2,3-d]-
pyrimidine-2,7-diamine;
- 1-[2-Amino-6-(2,3-dichlorophenyl)-
pyrido[2,3-d]pyrimidin-7-yl]-3-tert-butyl-urea;
- 1-[2-Amino-6-(2,6-difluoro-phenyl)-
pyrido[2,3-d]pyrimidin-7-yl]-3-tert-butyl-urea;
- 25 1-[2-Amino-6-(2,6-dibromo-phenyl)-
pyrido[2,3-d]pyrimidin-7-yl]-3-tert-butyl-urea;
- 1-[2-Amino-6-(2,6-dichlorophenyl)-
pyrido[2,3-d]pyrimidin-7-yl]-3-isopropyl-urea;
- 30 1-(2-Amino-6-phenyl-pyrido[2,3-d]pyrimidin-7-
yl)-3-tert-butyl-urea;
- 1-[2-Amino-6-(2,3-dimethyl-phenyl)-
pyrido[2,3-d]pyrimidin-7-yl]-3-tert-butyl-urea;
- 1-[2-Amino-6-(3,5-dimethyl-phenyl)-
pyrido[2,3-d]pyrimidin-7-yl]-3-tert-butyl-urea;
- 35

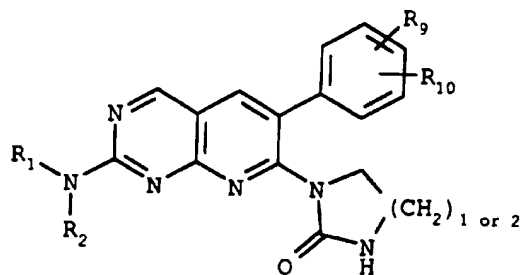
-121-

1-[2-Amino-6-(2-methoxy-phenyl)-
pyrido[2,3-d]pyrimidin-7-yl]-3-tert-butyl-urea;

1-[2-Amino-6-(3-methoxy-phenyl)-
pyrido[2,3-d]pyrimidin-7-yl]-3-tert-butyl-urea;
and

1-[2-Amino-6-(2-bromo-6-chloro-phenyl)-
pyrido[2,3-d]pyrimidin-7-yl]-3-tert-butyl-urea.

21. A compound of Claim 1 having the formula

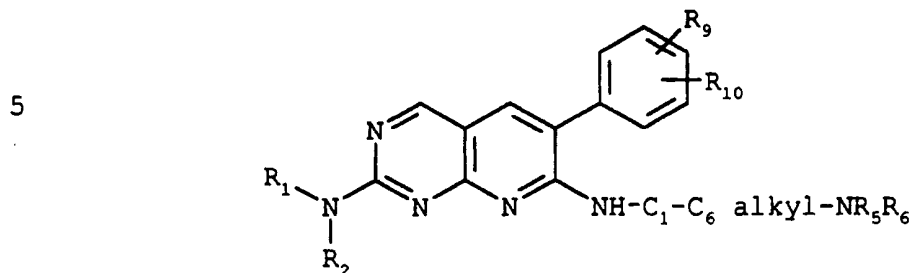


wherein R₁, R₂, R₉, and R₁₀ are as defined in
Claim 1.

22. A compound of Claim 21 wherein R₉ and R₁₀ both are
halo or methyl.
23. A compound of Claim 22 wherein R₁ and R₂ both are
hydrogen.
24. The compound of Claim 23 which is 1-[2-amino-6-
(2,6-dichlorophenyl)-pyrido[2,3-d]pyrimidin-7-yl]-
imidazolidin-2-one.

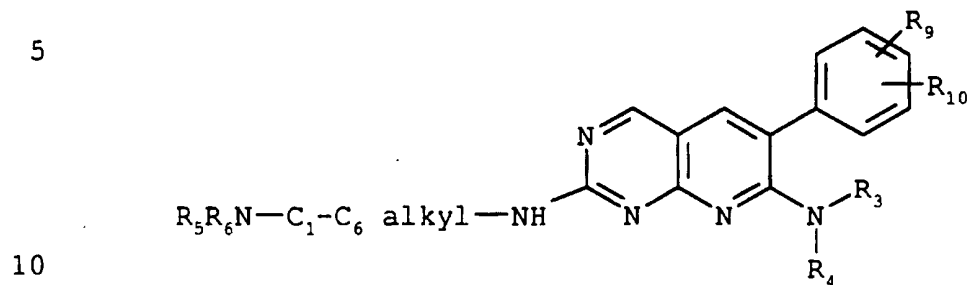
-122-

25. A compound of Claim 1 having the formula



wherein R_1 , R_2 , R_5 , R_6 , R_9 , and R_{10} are as defined in Claim 1.

26. A compound of Claim 1 having the formula



27. A compound of Claim 26 wherein R_3 is $\overset{\text{O}}{\parallel}\text{-CR}_8$ and R_4 is hydrogen.

28. A compound of Claim 27 which is

1-tert-Butyl-3-[6-(2,6-dichlorophenyl)-2-(3-diethylamino-propylamino)-pyrido[2,3-d]-pyrimidin-7-yl]-urea;

5 1-tert-Butyl-3-[6-(2,6-dichlorophenyl)-2-(3-dimethylamino-propylamino)-pyrido[2,3-d]pyrimidin-7-yl]-urea;

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- 10 1-tert-Butyl-3-[6-(2,6-dichlorophenyl)-2-(3-dimethylamino-2,2-dimethyl-propylamino)-pyrido[2,3-d]pyrimidin-7-yl]-urea;
- 1-tert-Butyl-3-[6-(2,6-dichlorophenyl)-2-[3-(2-methyl-piperidin-1-yl)-propylamino]-pyrido[2,3-d]pyrimidin-7-yl]-urea;
- 15 1-[6-(2,6-Dichlorophenyl)-2-(4-diethylamino-butylamino)-pyrido[2,3-d]pyrimidin-7-yl]-3-phenyl-urea;
- 1-[6-(2,6-Dichlorophenyl)-2-(4-diethylamino-butylamino)-pyrido[2,3-d]pyrimidin-7-yl]-3-ethyl-urea;
- 20 1-[6-(2,6-Dichlorophenyl)-2-(4-diethylamino-butylamino)-pyrido[2,3-d]pyrimidin-7-yl]-3-ethyl-urea, hydrochloride salt;
- 1-Cyclohexyl-3-[6-(2,6-dichlorophenyl)-2-(4-diethylamino-butylamino)-pyrido[2,3-d]pyrimidin-7-yl]-urea;
- 25 1-tert-Butyl-3-[6-(2,6-dibromo-phenyl)-2-(3-diethylamino-propylamino)-pyrido[2,3-d]pyrimidin-7-yl]-urea;
- 1-tert-Butyl-3-[6-(2,6-dichlorophenyl)-2-(2-diethylamino-ethylamino)-pyrido[2,3-d]-pyrimidin-7-yl]-urea;
- 30 1-[6-2,6-Dichlorophenyl)-2-(2-diethylamino-ethylamino)-pyrido[2,3-d]pyrimidin-7-yl]-3-ethyl-urea;
- 35 1-tert-Butyl-3-[6-(2,6-dichlorophenyl)-2-[(3-dimethylamino-propyl)-methyl-amino]-pyrido[2,3-d]-pyrimidin-7-yl]-urea;
- 1-[6-(2,6-Dichlorophenyl)-2-(3-diethylamino-propylamino)-pyrido[2,3-d]pyrimidin-7-yl]-3-ethyl-urea;
- 40 1-[6-(2,6-Dichlorophenyl)-2-(3-diethylamino-propylamino)-pyrido[2,3-d]pyrimidin-7-yl]-3-isopropyl-urea;

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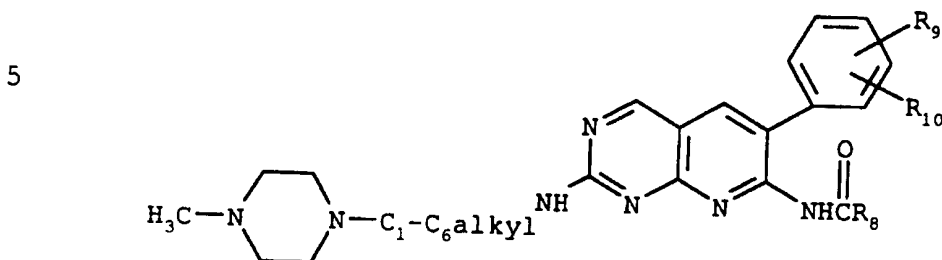
45 1-[2-(3-Dimethylamino-propylamino)-6-(2,6-dimethyl-phenyl)-pyrido[2,3-d]pyrimidin-7-yl]-3-ethyl-urea;

1-tert-Butyl-3-[2-(3-diethylamino-propylamino)-6-(2,6-dimethyl-phenyl)-pyrido[2,3-d]pyrimidin-7-yl]-urea;

50 1-tert-Butyl-3-[6-(2,6-dichlorophenyl)-2-(4-diethylamino-butylamino)-pyrido[2,3-d]pyrimidin-7-yl]-urea; and

55 1-[6-(2,6-Dichlorophenyl)-2-(4-diethylamino-butylamino)-pyrido[2,3-d]pyrimidin-7-yl]-3-ethyl-urea.

29. A compound of Claim 27 having the formula



30. A compound of Claim 29 which is

1-tert-Butyl-3-(6-(2,6-dichlorophenyl)-2-[4-(4-methyl-piperazin-1-yl)-butylamino]-pyrido[2,3-d]pyrimidin-7-yl)-urea;

5 1-Cyclohexyl-3-(6-(2,6-dichlorophenyl)-2-[3-(4-methyl-piperazin-1-yl)-propylamino]-pyrido[2,3-d]pyrimidin-7-yl)-urea;

10 1-(6-(2,6-Dichlorophenyl)-2-[3-(4-methyl-piperazin-1-yl)-propylamino]-pyrido[2,3-d]pyrimidin-7-yl)-3-isopropyl-urea;

1-Benzyl-3-(6-(2,6-dichlorophenyl)-2-[3-(4-methyl-piperazin-1-yl)-propylamino]-pyrido[2,3-d]pyrimidin-7-yl)-urea;

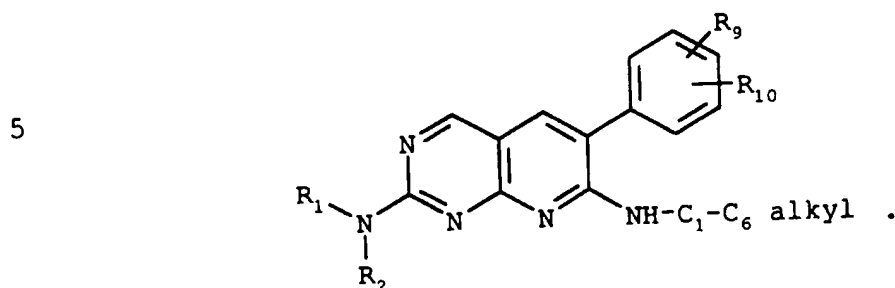
-125-

- 15 1-Allyl-3-(6-(2,6-dichlorophenyl)-2-[3-(4-methyl-piperazin-1-yl)-propylamino]-pyrido[2,3-d]-pyrimidin-7-yl)-urea;
- 20 1-(6-(2,6-Dichlorophenyl)-2-[3-(4-methyl-piperazin-1-yl)-propylamino]-pyrido[2,3-d]-pyrimidin-7-yl)-3-(4-methoxy-phenyl)-urea;
- 1-(6-(2,6-Dichlorophenyl)-2-[3-(4-methyl-piperazin-1-yl)-propylamino]-pyrido[2,3-d]-pyrimidin-7-yl)-3-(3-methoxy-phenyl)-urea;
- 25 1-(6-(2,6-Dichlorophenyl)-2-[3-(4-methyl-piperazin-1-yl)-propylamino]-pyrido[2,3-d]-pyrimidin-7-yl)-3-(2-methoxy-phenyl)-urea;
- 1-(4-Bromo-phenyl)-3-(6-(2,6-dichlorophenyl)-2-[3-(4-methyl-piperazin-1-yl)-propylamino]-pyrido[2,3-d]pyrimidin-7-yl)-urea;
- 30 1-(4-Chloro-phenyl)-3-(6-(2,6-dichlorophenyl)-2-[3-(4-methyl-piperazin-1-yl)-propylamino]-pyrido[2,3-d]pyrimidin-7-yl)-urea;
- 1-(6-(2,6-Dichlorophenyl)-2-[3-(4-methyl-piperazin-1-yl)-propylamino]-pyrido[2,3-d]-pyrimidin-7-yl)-3-p-tolyl-urea;
- 35 1-(6-(2,6-Dichlorophenyl)-2-[3-(4-methyl-piperazin-1-yl)-propylamino]-pyrido[2,3-d]-pyrimidin-7-yl)-3-octyl-urea;
- 1-(6-(2,6-Dichlorophenyl)-2-[3-(4-methyl-piperazin-1-yl)-propylamino]-pyrido[2,3-d]-pyrimidin-7-yl)-3-(4-trifluoromethyl-phenyl)-urea;
- 40 1-(6-(2,6-Dichlorophenyl)-2-[3-(4-methyl-piperazin-1-yl)-propylamino]-pyrido[2,3-d]-pyrimidin-7-yl)-3-ethyl-urea;
- 1-(6-(2,6-Dichlorophenyl)-2-[3-(4-methyl-piperazin-1-yl)-propylamino]-pyrido[2,3-d]-pyrimidin-7-yl)-3,3-diethyl-urea;
- 45 1-(6-(2,6-Dichlorophenyl)-2-[3-(4-methyl-piperazin-1-yl)-propylamino]-pyrido[2,3-d]-pyrimidin-7-yl)-3-naphthalen-1-yl-urea;

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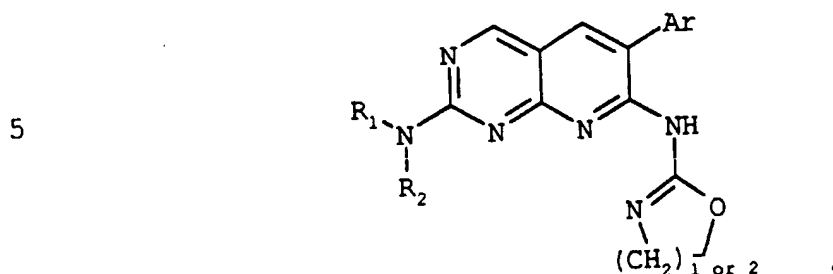
- 50 1-(6-(2,6-Dichlorophenyl)-2-[3-(4-methyl-
piperazin-1-yl)-propylamino]-pyrido[2,3-d]-
pyrimidin-7-yl)-3-phenyl-urea;
1-tert-Butyl-3-(6-(2,6-dichlorophenyl)-2-[3-
(4-methyl-piperazin-1-yl)-propylamino]-pyrido-
55 [2,3-d]pyrimidin-7-yl)-urea;
1-Adamantan-1-yl-3-(6-(2,6-dichlorophenyl)-2-
[3-(4-methyl-piperazin-1-yl)-propylamino]-pyrido-
[2,3-d]pyrimidin-7-yl)-urea; and
1-tert-Butyl-3-(2-[3-(4-methyl-piperazin-
60 1-yl)-propylamino]-6-(2,3,5,6-tetramethyl-phenyl)-
pyrido[2,3-d]pyrimidin-7-yl)-urea.

31. A compound of Claim 1 having the formula



32. The compound of Claim 31 which is
6-(4-methoxyphenyl)-N⁷-methyl-pyrido[2,3-d]-
pyrimidine-2,7-diamine.

33. A compound of Claim 1 having the formula

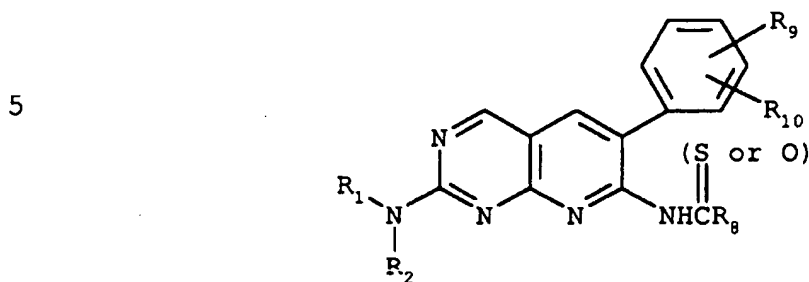


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34. The compound of Claim 33 which is
 2-[2-Amino-6-(2,6-dichlorophenyl)-
 pyrido[2,3-d]pyrimidin-7-yl]-amino-
 4,5-dihydrooxazole; and

5 6-(2,6-Dichlorophenyl)-N²-[3-(4-methyl-
 piperazin-1-yl)-propyl]-N⁷-(5,6-dihydro-4H-
 [1,3]oxazin-2-yl)-pyrido[2,3-d]pyrimidin-2,7-
 diamine.

35. A compound of Claim 1 having the formula



36. A compound of Claim 35 which is

1-[2-Amino-6-(2,6-dichlorophenyl)-pyrido-
 [2,3-d]pyrimidin-7-yl]-3-(3-morpholin-4-yl-
 propyl)-thiourea;

5 1-Butyl-3-[7-(3-butyl-ureido)-6-(2,6-
 dichlorophenyl)-pyrido[2,3-d]pyrimidin-2-yl]-urea;

1-[2-Amino-6-(2,6-dichlorophenyl)-
 pyrido[2,3-d]pyrimidin-7-yl]-3-propyl-urea;

10 1-tert-Butyl-3-[6-(2,6-dichlorophenyl)-2-(3-
 morpholin-4-yl-propylamino)-pyrido[2,3-d]-
 pyrimidin-7-yl]-urea;

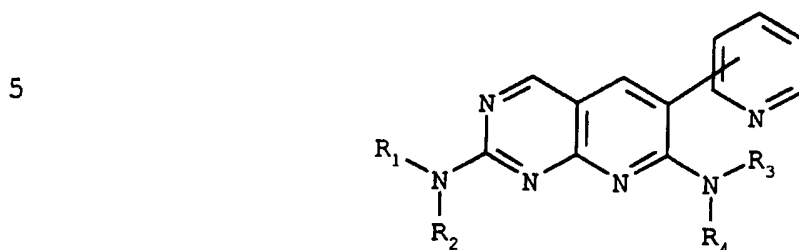
1-tert-Butyl-3-[6-(2,6-dichlorophenyl)-2-
 [3-(4-methyl-piperazin-1-yl)-propylamino]-pyrido-
 [2,3-d]pyrimidin-7-yl]-thiourea;

15 1-tert-Butyl-3-[6-(2,6-dichlorophenyl)-2-
 [N-(3-dimethylaminopropyl)-N-methylamino]-
 pyrido[2,3-d]pyrimidin-7-yl]-urea;

-128-

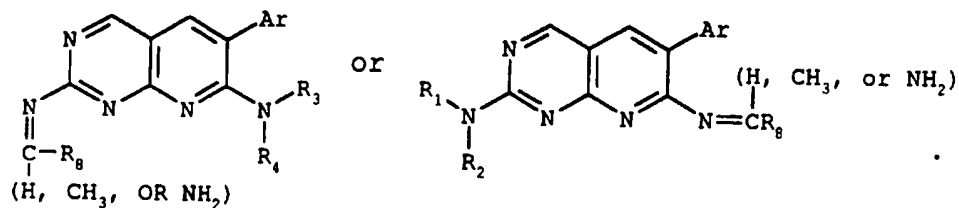
- 20 1-[6-(2,6-Dichlorophenyl)-2-(4-diethylamino-butylamino)-pyrido[2,3-d]pyrimidin-7-yl]-3-(3-morpholin-4-yl-propyl)-thiourea; and
- 1-tert-Butyl-3-[6-(2,6-dichlorophenyl)-2-[N-(3-dimethylaminopropyl)-N-methylamino]-pyrido[2,3-d]pyrimidin-7-yl]-urea.

37. A compound of Claim 1 having the formula



38. A compound of Claim 37 which is
- 1-[2-Amino-6-(pyridin-2-yl)-pyrido[2,3-d]-pyrimidin-7-yl]-3-tert.-butyl-urea;
- 1-[2-Amino-6-(pyridin-3-yl)-pyrido[2,3-d]-pyrimidin-7-yl]-3-tert-butyl-urea; and
- 5 1-[2-Amino-6-(pyridin-4-yl)-pyrido[2,3-d]-pyrimidin-7-yl]-3-tert-butyl-urea.

39. A compound of Claim 1 having the formula



40. A compound of Claim 39 which is
- N-[6-(2,6-Dichlorophenyl)-2-(3-diethylamino-propylamino)-pyrido[2,3-d]pyrimidin-7-yl-N'-ethyl-guanidine;

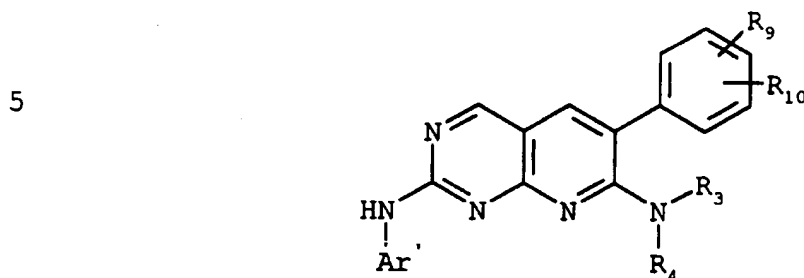
-129-

5 N'-[6-(2,6-dichlorophenyl)-2-{3-(diethylamino)propylamino}pyrido[2,3-d]pyrimidin-7-yl]-N,N-dimethylformamide;

10 N'-[6-(2,6-dichlorophenyl)-7-[(dimethylamino)methyleneamino]-pyrido[2,3-d]pyrimidin-2-yl]-N,N-dimethylformamide; and

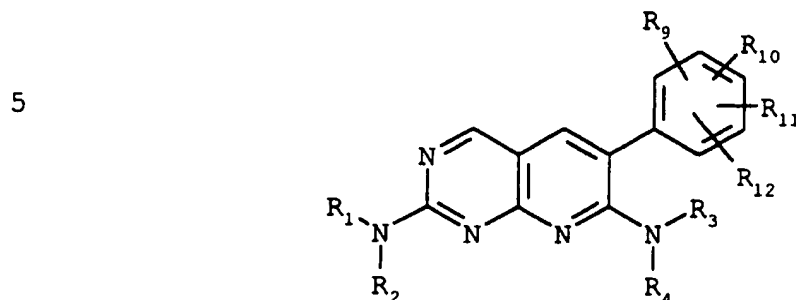
N'-[7-(3-tert-Butylureido)-6-(2,6-dichlorophenyl)-pyrido[2,3-d]pyrimidin-2-yl]-N,N-dimethylformamide.

41. A compound of Claim 1 having the formula



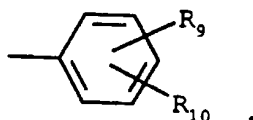
42. A compound of Claim 41 which is
1-tert.-Butyl-3-[[6-(2,6-dichlorophenyl)-2-phenylamino]-pyrido[2,3-d]pyrimidin-7-yl]-urea.

43. A compound of Claim 1 having the formula



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44. A compound of Claim 43 which is
1-[2-Amino-6-(2,3,5,6-tetramethyl-phenyl)-
pyrido[2,3-d]pyrimidin-7-yl]-3-tert-butyl-urea;
1-[2-Amino-6-(2,4,6-trimethyl-phenyl)-pyrido-
[2,3-d]pyrimidin-7-yl]-3-tert-butyl-urea; and
1-[2-Amino-6-(2,3,6-trichloro-phenyl)-pyrido-
[2,3-d]pyrimidin-7-yl]-3-tert-butyl-urea.
45. A compound of Claim 1 which is
Propane-1-sulfonic acid [2-amino-6-(2,6-
dichlorophenyl)-pyrido[2,3-d]pyrimidin-7-yl]-
amide.
46. A pharmaceutical formulation comprising a compound
of Claim 1 together with a pharmaceutically
acceptable carrier, diluent, or excipient
therefor.
47. A formulation of Claim 46 employing a compound
wherein B is NR_3R_4 .
48. A formulation of Claim 47 employing a compound
wherein X is CH.
49. A formulation of Claim 48 employing a compound
wherein Ar is an optionally substituted phenyl
ring of the formula



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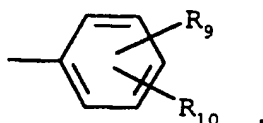
50. A formulation of Claim 49 employing a compound wherein R_2 and R_4 are hydrogen, and R_1 and R_3

5 independently are hydrogen, C_1 - C_6 alkyl, $\overset{\text{O}}{\underset{\text{S}}{\text{C}}}-R_8$ or $\overset{\text{S}}{\underset{\text{O}}{\text{C}}}-R_8$, where R_8 is C_1 - C_6 alkyl or $-NR_5R_6$.

51. A formulation of Claim 47 employing a compound wherein X is N.

52. A formulation of Claim 51 employing a compound wherein Ar is an optionally substituted phenyl ring of the formula

5



53. A formulation of Claim 52 employing a compound wherein R_2 and R_4 are hydrogen, and R_1 and R_3

5 independently are hydrogen, C_1 - C_6 alkyl, $\overset{\text{S}}{\underset{\text{O}}{\text{C}}}-R_8$ or $\overset{\text{O}}{\underset{\text{S}}{\text{C}}}-R_8$, where R_8 is C_1 - C_6 alkyl or $-NR_5R_6$.

54. A method of treating vascular smooth muscle proliferative disease including atherosclerosis and postsurgical restenosis comprising administering to a host suffering therefrom a therapeutically effective amount of a compound according to Claim 1 in unit dosage form.

5

55. A method of inhibiting cell proliferation and migration comprising administering to a host

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5 suffering therefrom a therapeutically effective amount of a compound according to Claim 1 in unit dosage form.

56. A method for treating psoriasis comprising administering to a host suffering therefrom a therapeutically effective amount of a compound according to Claim 1.
57. A method of inhibiting epidermal growth factor receptor tyrosine kinase by administering an effective inhibiting amount to a mammal in need thereof a compound of Claim 1.
58. A method of inhibiting Erb-B2 or Erb-B3 or Erb-B4 tyrosine kinase by administering an effective inhibiting amount to a mammal in need thereof a compound of Claim 1.
59. A method of inhibiting protein tyrosine kinases by administering an effective inhibiting amount to a mammal in need thereof a compound of Claim 1.
60. A method of inhibiting C-src tyrosine kinase by administering an effective inhibiting amount to a mammal in need thereof a compound of Claim 1.
61. A method of inhibiting V-src tyrosine kinase by administering an effective inhibiting amount to a mammal in need thereof a compound of Claim 1.
62. A method of inhibiting basic fibroblast growth factor and/or acidic fibroblast growth factor receptor tyrosine kinase by administering an effective inhibiting amount to a mammal in need thereof a compound of Claim 1.

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63. A method of treating bacterial infections in a mammal comprising administering an antibacterially effective amount of a compound of Claim 1.
64. A method for treating restenosis in a mammal comprising administering an effective amount of a compound of Claim 1.
65. A method for treating restenosis of coronary arteries following balloon angioplasty comprising administering to a subject in need of treatment an effective amount of a compound of Claim 1.
66. A method of inhibiting stenosis following transplant of an organ in normal comprising administering an effective amount of a compound of Claim 1.
67. A method of inhibiting bypass graft stenosis to a subject in need of treatment an effective amount a compound of Claim 1.
68. A method of inhibiting stenosis following a venous graft comprising administering an effective inhibiting amount of a compound of Claim 1.
69. A method of inhibiting restenosis of peripheral vessels following angioplasty comprising administering an effective amount of a compound of Claim 1.
70. A method of inhibiting platelet derived growth factor receptor tyrosine kinase by administering an effective inhibiting amount to a mammal in need thereof a compound of Claim 1.

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(54) Title: 6-ARYL PYRIDO[2,3-d]PYRIMIDINES AND NAPHTHYRIDINES FOR INHIBITING PROTEIN TYROSINE KINASE
MEDIATED CELLULAR PROLIFERATION

7) Abstract

6-Aryl pyrido[2,3-d]pyrimidines and naphthyridines are inhibitors of protein tyrosine kinase, and are thus useful in treating cellular
proliferation mediated thereby. The compounds are especially useful in treating atherosclerosis, restenosis, psoriasis, as well as bacterial
infections.

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INTERNATIONAL SEARCH REPORT

Int. Application No
PCT/US 95/14700

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 C07D471/04 A61K31/44 A61K31/505 //(C07D471/04,221:00,
221:00), (C07D471/04,239:00,221:00)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 C07D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JOURNAL OF MEDICINAL CHEMISTRY, vol. 26, no. 3, 1983, pages 403-411, XP002000852 C. J. BLANKLEY ET AL.: "Antihypertensive Activity ..." see page 407, Table I, compound 39	1,2,4,14
A	--- JOURNAL OF MEDICINAL CHEMISTRY, vol. 24, no. 4, 1981, pages 382-389, XP002000853 L. R. BENNETT ET AL.: "Antihypertensive Activity ..." see page 386, Table III, compound no. 1	1,2,4,14
A	--- US,A,3 534 039 (J. DAVOLL) 13 October 1970 cited in the application see claims --- -/--	1,2,4,14

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

18 April 1996

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Hass, C

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 95/14700

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US,A,3 639 401 (R. F. MEYER) 1 February 1972 cited in the application see claims ---	1,2,4,14
A	US,A,4 271 164 (C. J. BLANKLEY ET AL.) 2 June 1981 cited in the application see claims 1-3 -----	1,2,4,14

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US95/14700

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
Although claims 54-70 are directed to a method of treatment of (diagnostic method practised on) the human/animal body, the search has been carried out and based on the alleged effects of the compound/composition.
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

Int. J. Application No

PCT/US 95/14700

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A-3534039	13-10-70	BE-A- 723660	16-04-69
		CH-A- 500204	15-12-70
		CH-A- 501000	31-12-70
		CH-A- 501001	31-12-70
		CH-A- 501002	31-12-70
		CH-A- 507267	15-05-71
		DE-A- 1807887	21-05-70
		FR-M- 8247	12-10-70
		FR-A- 1594755	08-06-70
		GB-A- 1171218	19-11-69
		NL-A- 6815963	13-05-69

US-A-3639401	01-02-72	NONE	

US-A-4271164	02-06-81	AT-T- 5968	15-02-84
		AU-B- 5733380	23-10-80
		EP-A,B 0018151	29-10-80
		JP-C- 1457923	09-09-88
		JP-A- 55160776	13-12-80
		JP-B- 63004538	29-01-88

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